PERMEABLE REACTIVE BARRIER TREATMENT
SOUTH LANDFILL
NEWPORT SUPERFUND SITE
NEWPORT, DELAWARE

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DU PONT ◆

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EXECUTIVE SUMMARY

DuPont proposes an innovative technology for treating waste in the South Landfill at the Newport Superfund site. Permeable reactive barrier (PRB) technology and an engineered cap are proposed as a protective and cost-effective alternative to both the treatment remedy described in the 1993 Record of Decision (ROD) and the in situ chemical treatment remedy described in the 1995 Explanation of Significant Differences (ESD). This proposal supports a new treatment technology which has been demonstrated with both laboratory and field demonstrations.

The National Contingency Plan (NCP) indicates a preference for innovative technologies that offer comparable or superior performance, fewer adverse impacts than other available approaches, or lower costs for similar levels of performance than demonstrated technologies. The DuPont Newport Superfund site ROD required treatment of the waste materials located in the South Landfill using soil mixing. New data indicate that the cost of the ROD remedy exceeds $16MM. The ESD remedy specified in situ chemical treatment. The ESD remedy with subsequent modifications (calcium sulfate and a single barrier cap without groundwater controls or a slurry wall) would cost approximately $6MM.

The PRB alternative treatment remedy provides greater protection of human health and the environment while being more cost-effective than soil mixing or in situ chemical treatment. This innovative technology meets the statutory preference for treatment by immobilizing the metals of concern, minimizing the waste volumes, and provides protectiveness for hundreds of years. DuPont estimates that the cost of the alternative is $3MM.

This document describes a permeable reactive barrier and modified cap remedy (PRB remedy) and provides laboratory and field data to support the feasibility of the proposed approach.

A supplemental study is proposed to establish background manganese concentrations in the fill zone outside of the South Landfill. Local background concentrations are a more appropriate performance standard than the currently established one for manganese.

Section 1.0 provides an overview of the proposed remedy and its appropriateness for the South Landfill as well as its suitability for consideration in the context of Superfund. Section 1.1 describes new data collected since the 1995 ESD. Section 1.2 describes the PRB technology for the South Landfill waste and the complete remedy now being proposed for the South Landfill. The remedial benefits of the proposed remedy are summarized in Section 1.3. The organization of this document is described in Section 1.4.

1.1   SUMMARY OF NEW DATA

Since the 1995 ESD for the Newport Superfund site, considerable additional information has been collected that impacts prior assessments and supports a new, innovative, cost-effective treatment technology:

❑ Laboratory testing showed that the in situ chemical treatment remedy (ESD) requires considerably more treatment agent (~10X) than realized when the ESD was proposed due to the demand of the landfilled waste. The cost, feasibility, and waste generation due to placing over 70 million pounds of sodium sulfate in the landfill had not been considered in the prior proposal. Chemical costs, alone, exceeded $15MM.

❑ PRB treatment has been demonstrated successfully in laboratory and field testing. The reactive agents are calcium sulfate (gypsum) for barium immobilization and zero-valent iron for zinc immobilization. The reactive materials are placed in a trench with inert soil (Del DOT mason sand) at a soil: gypsum: iron ratio of 100:20:5 by weight. The PRB uses 97% less agent to accomplish treatment.

❑ Barium, zinc, and all mobile constituents, except manganese, are immobilized by the PRB remedy to well below the treatment standards established in the ESD. A wall life of hundreds of years is achieved with a single barrier-layer cap permeability of 10^{-7} cm/sec.

❑ Perimeter Geoprobe® data has delineated the aerial extent of the landfill on both sides of Basin Road and the depth to the marsh deposit, the confining unit under the South Landfill.

❑ Groundwater samples in the South Landfill have shown that barium exceeds the performance standard throughout and zinc is elevated in only a few areas. Lead and manganese have isolated exceedances of the performance standard.

❑ Groundwater samples on the landfill perimeter confirm the barium exceedances. Zinc is elevated in limited areas. Manganese is also elevated at the landfill perimeter. The lead standard is not exceeded. No other exceedances are apparent.

❑ Historical manganese concentrations in fill zone groundwater both inside and outside of the site indicate background manganese levels may exceed the treatment standard.

❑ Permeable reactive barrier technologies can be implemented with conventional slurry wall construction methods.

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❑ The ROD and ESD remedies will require two construction seasons to implement. Mixing alone will require more than a year to complete. The PRB remedy can be implemented in a single construction season.

This new data indicate that a PRB and modified cap will provide a better remedy than either the ROD or ESD remedies. That is, the PRB is more permanent, implementable, and cost-effective. The PRB remedy will not increase the waste volume and will provide equal or better protection of human health and the environment. This technology can be applied simply and effectively using proven trench excavation equipment while reducing the time required for treatment to one year.

1.2   SOUTH LANDFILL REMEDY

The South Landfill was previously used for the disposal of lithophone waste materials. These waste materials are composed of spent ores containing residues of several heavy metals, primarily barium and zinc. The ROD- and ESD-specified remedies address the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) statutory preference for treatment to reduce the mobility, toxicity, or volume of the heavy metals. The PRB also provides demonstrated immobilization of metals with lower waste volumes and is supported by long-term monitoring to ensure background levels are achieved. The modified (single-barrier) cap reduces groundwater infiltration and extends wall life.

The following are the essential elements of the proposal:

❑ Immobilization treatment provided by a permeable reactive barrier containing gypsum, iron and inert soil along two of the three sides of the landfill (see Figure 1).

❑ Control of groundwater migration by placing a soil-bentonite slurry wall along the river side of the landfill (see Figure 1).

❑ Cap consisting of a single, low permeability barrier covering the entire landfill.

❑ Geomembrane and stone placed along the riverbank for containment and erosion control.

❑ Monitoring to ensure successful treatment effectiveness, wall life, and containment.

DuPont envisions the following sequence of events:

❑ *Grading of the Landfill Surface*
The holding cell on the South Landfill containing South Wetlands and Christina sediments will be graded to accommodate the final cover.

❑ *Soil-Bentonite Slurry Wall and Permeable Reactive Barrier*
A soil-bentonite slurry wall will be constructed along the south side of the New Castle County sewer line. A permeable reactive barrier will be constructed along the remaining two sides of the South Landfill, extending to the marsh deposit and connecting with the slurry wall, circumscribing the landfill material. The barriers will cross Old Airport Road twice. Figure 1 shows a plan view of the proposed alignment.

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❑ *Treatment*

The permeable reactive barrier will be constructed of a 100:20:5 weight ratio of inert soil, gypsum, and zero-valent iron. Section 3.0 presents a complete description of treatment by the permeable reactive barrier.

❑ *Low Permeable Cover*

The final cover system will be composed of a single barrier of less than 10^{-7} cm/sec permeability, such as a geosynthetic clay liner. Figure 2 shows the conceptual cap design. The cap will extend across the sewer line to the top of the riverbank.

❑ *Riverbank Stabilization*

The intertidal zone along the Christina River will be stabilized with a geosynthetic membrane, stone, and soil.

❑ *Monitoring*

Groundwater passing through the PRB will be monitored to ensure the primary metals are immobilized. Groundwater outside of the landfill will be monitored to ensure manganese is attenuated to background levels. The riverbank will be inspected to ensure containment.

1.3 REMEDIAL BENEFITS

This remedial proposal enhances the remedy described in both the 1993 ROD and the 1995 ESD because it:

❑ Satisfies the nine selection criteria as do the ROD and ESD.

❑ Meets the remedial objectives of the ROD.

❑ Complies with applicable and relevant or appropriate requirements (ARARs).

❑ Is more permanent, effective, implementable, and cost-effective.

❑ Complies with the preference for treatment without increasing waste volumes.

❑ Provides greater protection of human health and the environment.

Greater benefit is achieved by using proven installation methods and physical containment of the waste. Containment is provided by the low-permeability cap and circumscribing vertical barrier tied into a continuous confining layer. This proposal also shortens the construction schedule for the South Landfill to one construction season.

PRB treatment is an innovative approach to immobilizing metals of concern. By limiting infiltration with a low-permeability cap, the life of the reactive wall is extended to hundreds of years.

Other features of the remedy are its ease of implementation, extended remedy life, monitoring, and simplicity. Standard, readily available equipment will be used to install the reactive barrier. Treatment effectiveness is easily assessed by monitoring groundwater quality in the barrier.

1.4   DOCUMENT ORGANIZATION

Waste containment with a slurry wall – PRB and single barrier cap are described in more detail in Section 2. Section 3 discusses the new data developed in support of the permeable reactive barrier in detail. Section 4 contains a comparison of the ROD, ESD and PRB Remedies. Section 5 describes the remedial goals, the elements of the proposed remedy, and proposes appropriate performance standards. Conclusions and recommendations are included in Section 6.

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Section 2 describes the waste containment aspects of the proposal that complement the proposed treatment (see Section 3.0). The proposed waste containment system for the South Landfill will physically separate the waste material from the environment and hydraulically control groundwater migration.

The conceptual approach for containment of the waste is described in Section 2.1. The placement of the slurry wall and the PRB, including wall alignment and materials of construction, are discussed in Section 2.2. The cap is presented in Section 2.3.

2.1 WASTE CONTAINMENT CONCEPTUAL APPROACH

DuPont proposes a complete barrier system to physically separate the waste material from the environment. The barrier system will consist of a soil-bentonite slurry wall extending vertically into the low-permeability confining layer below the landfill. The slurry wall will be placed parallel to and on the south side of the New Castle County sewer line. In addition, a permeable reactive barrier will surround the remainder of the landfill. Both barriers will be tied into the relatively impermeable marsh deposit below the landfill (see Figure 1).

In addition, the cap will extend across the sewer line to the top of the riverbank (see Figure 1). The riverbank will be stabilized with geomembrane, stone, and soil (EPA 1996). The landward slurry wall, cap, and riverbank cover will prevent further migration through the waste material not contained within the circumscribing wall. The geotextile, stone, and soil will prevent further erosion and complete containment of the waste.

The low-permeability marsh deposit confining layer will form the bottom of the containment system. This layer is continuous and at least 10 feet thick so that an adequate "key" can be made. The existing cover soil and the low-permeability geomembrane cap on the South Landfill will completely separate the waste from the environment. The geologic occurrence (continuity and thickness) and hydraulic characteristics (permeability) of the confining layer found beneath the South Landfill waste material has previously been described (DERS 1995).

2.2 SOIL-BENTONITE SLURRY WALL AND PERMEABLE REACTIVE BARRIER

The South Landfill will be contained with a vertical barrier consisting of a slurry wall and permeable reactive barrier. As shown in the ESD proposal, the South Landfill site and subsurface conditions are ideal for a soil-bentonite slurry wall. The topography is relatively flat, and the depth to the confining layer is shallow enough (less than 30 feet) to use conventional backhoes for excavation. In addition, construction quality control and quality assurance procedures are well established for slurry walls to ensure continuity and low permeability.

A soil-bentonite slurry wall is proposed along the river side of the landfill because landfill materials have been previously found at the riverbank. It is impossible to contain the waste within a reactive barrier; hence, this barrier contains the remaining waste by physical and hydraulic isolation under a low-permeability cap.

The slurry wall and reactive barrier will contain, to the extent practical, all of the waste material within the South Landfill, as shown on Figure 1. The alignment is based on EPA's agreement (EPA, 1996b) that the wall can be placed on the south side of the New Castle County sewer main. EPA approved this location because the residual risk from the untreated material covered by a geomembrane and stone and the ecological benefit of allowing trees to remain along the riverbank was less than the risk of a catastrophic sewer line failure. The aerial extent on the north and east has been confirmed with recent Geoprobe® borings (see Appendix C).

The soil-bentonite slurry wall will be designed to have a maximum permeability of 1×10^{-7} cm/sec. The slurry wall will be a minimum 36-inch-wide wall, with a 3-foot key into the clayey silt layer. The soil-bentonite backfill will consist of clean backfill mixed with bentonite slurry (EPA 1996a). Final design studies will be necessary to prepare the design and construction documents, including subsurface investigation, compatibility testing, slurry wall design, and a construction bidding document.

The permeable reactive barrier will be a minimum 36-inch-wide wall with a 3-foot key into the clayey-silt marsh deposit. The barrier will be a mixture of treatment agents and clean soil in the weight ration of 100:20:5 (soil: gypsum: iron). All groundwater originating from the waste material will pass through the permeable barrier. The PRB contains slightly soluble gypsum and insoluble iron, with a wall life of hundreds of years with a single barrier layer.

2.3 SINGLE BARRIER CAP

The cap will cover all of the waste material and extend beyond the limits of the slurry wall and reactive barrier. The cap will have a maximum permeability of 1×10^{-7} cm/sec. The cap will be designed as shown in Figure 2. The design includes a barrier layer (such as geocomposite clay liner (gcl) or clay), protective soil, and topsoil.

Infiltration through the cap was estimated with the Hydrogeologic Evaluation of Landfill Performance (HELP) model to determine cap performance (see Appendix B). A single barrier cap, such as gcl, reduces infiltration over 99% from current conditions. The difference between a singe barrier of gcl and the dual barrier specified in the existing performance standard (or single geosynthetic membrane) is not measurable (0.01995 in/yr. or 0.016 gal/min passing through the wall).

The cap design is a change from the ESD requirement for a dual-barrier cap with a synthetic geomembrane. Reducing groundwater to the maximum extent practical was a critical element of the ESD remedy because the treatment agents were extremely soluble and could be flushed from the waste by infiltrating rainwater.

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This section presents the laboratory and field data which support the conceptual design of the permeable reactive barrier.

3.1 PERMEABLE REACTIVE BARRIER

A permeable reactive barrier is an in-ground placement of active materials in the path of flowing groundwater. Laboratory and field tests showed aqueous contaminants will be removed as groundwater passes through the barrier. Metals were removed by precipitation and sorption. The barrier will be of sufficient width to provide adequate residence time and long-term capacity (hundreds of years), and deep enough to key into impermeable layers at the base of an aquifer. Once installed, the barrier will require virtually no routine maintenance, only groundwater monitoring to ensure treatment.

To evaluate PRB technology for metals treatment at the Newport South Landfill, a series of batch and column experiments was performed. First, screening batch tests were conducted with materials, which potentially could remove the metals. Two materials, gypsum ($CaSO_4.2H_2O$) and zero-valent iron (iron), showed excellent removal properties for barium and zinc, respectively. Barium precipitates as barium sulfate; zinc is removed by adsorption.

Gypsum and iron were then used in continuous-flow column tests to demonstrate their effectiveness together and with the sand that would make up the bulk of the PRB. Wall life projections were then made based on the column tests and flows through the PRB under assumptions of different landfill cap configurations.

As a final technology demonstration, in situ field tests were constructed using a design previously used by the U.S. EPA and DuPont. A 12-inch diameter column of the PRB sand: gypsum: iron mix was placed in the ground in the presence of contaminated groundwater. A one-inch monitoring well was placed in the middle of the column prior to backfill. Performance was determined by sampling the water that had passed through six inches of reactive material. The results of these tests validated the laboratory projections.

3.1.1 Laboratory Evaluations

This section describes the laboratory evaluations that were performed to develop the permeable reactive barrier treatment technology. Appendix A describes the evaluations in detail.

Batch Tests

Batch tests screened potential treatment materials. Groundwater from two locations inside the South Landfill were tested, representing areas of high barium or zinc concentration. The barium-rich water was used to evaluate gypsum effectiveness. The zinc-rich water was used to evaluate the effectiveness of zero-valent iron, millscale, steel slag, and iron sulfide.

These tests covered a broad range of concentrations for each active material. Groundwater and the reactants were put in 125 cc polypropylene bottles, the headspace purged with nitrogen, and then agitated end-over-end for 24 hours. Samples of the liquid phase were then passed through a 0.45-micron filter and analyzed for the constituents of

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interest. Control samples followed the same procedures except that no reactive material was added.

Barium concentrations were reduced from 290,000 ppb to less than 500 ppb by the addition of 0.5 weight percent of gypsum. The resulting concentration was substantially lower than the required 7,800 ppb standard (see Appendix A).

Zinc concentrations were readily reduced from approximately 1,000 ppb to less than 10 ppb (vs. a goal of 120 ppb) by several materials, including zero-valent iron (Peerless -8 +50 mesh), iron sulfide, steel-process mill scale, and steel slag. The first two showed exceptional activity. Zero-valent iron (iron) was chosen for further evaluation due to its high activity and DuPont experience at other sites.

Of the other metals of concern, cadmium, copper and lead were less than the detection limits of 4 ppb in both feeds and treated waters. Nickel was less than the goal of 73 ppb in feeds and all treated waters, and was reduced in all cases except mill scale. Manganese was generally not reduced by the materials, and in some cases manganese levels increased as a result of treatment, although below the treatment performance standard of 1,000 ppb established in the ESD.

Column Tests

Continuous-flow column tests were conducted with the selected reactive agents – gypsum and iron. The column tests were performed to assess wall life (capacity), synergistic (or antagonistic) effects of combining the materials, and potential performance limitations (such as plugging). Two independent tests were run, on barium-rich and zinc-rich samples from South Landfill wells with the elevated barium and zinc concentrations.

The composition of groundwater leaving the landfill at any point is not known with certainty. Consequently, one wall composition was chosen to ensure treatment of both barium and zinc. Based on the batch tests and a projection of reactant needs, a mix composition was chosen with parts by weight of:

$$Sand : Gypsum : Iron \ = \ 100 : 20 : 5.$$

An inert material, mason sand – a standard Delaware Department of Transportation material, was chosen as the base material for the PRB. Permeability tests showed that 20 weight percent gypsum mixed with mason sand had a permeability of 6×10^{-4} cm/sec. Waste permeabilities ranged from 2×10^{-5} to 1×10^{-6} cm/sec (Kiber 2000). The permeable barrier will have a higher permeability than the landfill material, preventing a "bathtub" effect.

For the laboratory experiments, two independent column tests were run concurrently, one with barium-rich feed water and one with zinc-rich feed water. Each test consisted of a reactive column filled with the above mix, and a control column filled with sand alone. Pressure drop across the columns was measured to determine the permeability of the columns over time.

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Barium removal was readily accomplished from both the barium-rich and zinc-rich groundwaters. With the barium-rich feed, 500,000 ppb Ba was reduced to nominally 1,000 ppb. With the zinc-rich feed, 70,000 ppb Ba was reduced to nominally 100 ppb. These results were consistent over the one-month test, and demonstrated barium removal to well less than the 7,800 ppb limit.

Zinc removal was difficult to quantify due to analytical complexities (possible interferences, etc.), but the performance was clear. While the zinc-rich feed water varied from 100 to 1,000 ppb, zinc was consistently reduced to non-detect (25 ppb) in both the active and control columns over the one-month test. It appears that the mortar sand backfill has some limited affinity for metals adsorption. Thus zinc levels were well below the standard of 120 ppb.

Of the other metals of concern, cadmium, copper and lead were less than the detection level of 4 ppb in both feeds and treated waters. Nickel was less than 30 ppb in treated groundwater, well below the goal of 73 ppb. Manganese, up to 100 ppb in feeds, was observed in zinc water column effluents at 200 to 8,000 ppb. In barium-rich effluents, zinc was found at 2 ppb to non-detect (10 ppb) levels.

Reactive column flow and pressure drops were used to calculate the column material permeabilities after 45 days of flow. The hydraulic conductivity was 2.2×10^{-4} and 2.6×10^{-4} cm/sec for the zinc and barium columns, respectively, the same magnitude as the fresh mixture ($\sim 6 \times 10^{-4}$ cm/sec). No permeability decrease was thus observed over many simulated wall lifetimes, and wall plugging should not be expected to occur.

3.1.2   Field Demonstration

Two test boring clusters, each consisting of a treatment well and a control boring, were placed in locations that had shown elevated levels of barium and zinc in the Geoprobe® groundwater sampling (see Appendix C).

The Geoprobe® assessment was conducted to confirm the limits of the landfill and determine groundwater quality on the landfill perimeter. Each treatment boring consisted of a 12-inch diameter column of treatment material with a central 1-inch PVC pipe. Each control boring was placed about fifteen feet (up- or side-gradient) from their respective treatment pair and were similarly constructed except that clean sand was used in place of treatment material (see Figure 1). The PVC pipe was screened five feet from the bottom of each well. A standard bentonite seal was placed above the treatment material or clean sand.

The field demonstration confirmed the laboratory tests. Barium, zinc, cadmium, copper, nickel, and lead were treated to below their respective performance standards. Manganese levels were below the performance standard in the zinc-rich well and above the performance standard in the barium-rich well.

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Field Tests Procedure

Water was pumped from the wells between sampling events to simulate wall life. A maximum pumping rate for the field tests was calculated by multiplying the laboratory column test rate of 0.5 L/day by the ratio of the area of the field test to the laboratory column test. The calculated maximum pumping rate was 8.125 L/hr; the average actual pumping rate was 4.5 L/hr with a range of 3.0 to 6.3 L/hr. The test and control wells in each well cluster were pumped at the same rate using a dual-head peristaltic pump. Filtered groundwater samples were analyzed each day the test columns were pumped

Results

Barium removal was demonstrated in both the barium-rich and zinc-rich locations. At the barium-rich groundwater location, the barium concentration in the water from the control well ranged between 44,500 and 103,000 ppb, compared to a concentration range of 11 to 58 ppb from the treatment well. At the zinc-rich groundwater location, the barium concentration in the water from the control well ranged from 133,000 to 230,000 ppb, whereas the barium concentration in water from the treatment well ranged from 160 to 540 ppb. The results are tabulated in Tables C.2 through C.6 in Appendix C.

Zinc removal was difficult to observe because of the low zinc concentrations in both locations. The zinc concentrations in the zinc-rich control well ranged from 15 ppb to non-detect. All zinc concentrations in the water from the zinc-rich treatment boring were below 6 ppb and most were non-detect. In water from the barium-rich control well, the zinc concentration was never higher than 47 ppb. Zinc concentrations in the water from the treatment well were never above 9 ppb and were non-detect in all samples after the second day of the field test.

For other constituents of interest, cadmium, copper, lead, and nickel were nearly below their detection limits throughout the field tests. None were above the practical quantitation limit. Calcium was detected in water from the control wells, at an average of 20,000 ppb, and in much higher concentrations in water from the treatment wells (an average of 550,000 ppb). The higher calcium concentrations are the result of gypsum dissolution. Manganese was detected in water from the zinc-rich wells at levels below 1,000 ppb. Manganese was also below the treatment standard in the barium-rich control well. Water in the barium-rich treatment well was about 15,000 ppb, exceeding the treatment standard.

3.2 WALL LIFE PROJECTIONS

Three factors determine the wall life for the South Landfill PRB – groundwater contaminant levels, groundwater flow from the waste material, and reactant capacity. Groundwater contaminant levels are determined by waste characteristics. Groundwater flow can be controlled by the design of the landfill cap permeability (and subsequent infiltration). Reactant capacity is a function of gypsum solubility (gypsum must dissolve at a level greater than required for barium precipitation) and iron loading.

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The only factor that cannot be controlled is the concentration of contaminants in groundwater. Groundwater flow (cap permeability) and reactant capacity can be designed to ensure adequate wall life and long-term performance. Column test fluxes and HELP model calculations were used to project wall life.

Cap infiltration was estimated using the HELP (Hydrologic Evaluation of Landfill Performance) Model. The table below shows rainwater infiltration rates to the landfill through various cap types. The corresponding wall fluxes, the field years simulated by each day of laboratory column operation, and the wall life projected after 29 days of laboratory column operation. The detailed wall life calculations are included in Appendix B.

Permeable Reactive Barrier Wall Life Predictions from Laboratory Column Tests				
Cap Type	Infiltration Rate, in/yr.	Wall Flux, $cm^3/cm^2/day$	Field Years/ Lab Day	Wall Life, Years
Current Conditions (3 ft. soil)	6	1.24	0.054	1.5
Asphalt (4 in.) + Stone (8 in.)	0.1	0.0207	3.27	90
Soil (18 in.) + Drainage Layer + GCL	0.02	0.00413	16.4	450

This evaluation shows that a single barrier cap, such as a geocomposite clay liner, is adequate to ensure hundreds of years of capacity. These cases represent a wall only eight inches thick, the length of the treatment column. In practice, the wall will be two or three feet thick, thus giving an additional life factor of at least three times the lifetimes given above.

3.3   MANGANESE FATE AND TRANSPORT

3.3.1   Manganese Levels in Soil and Groundwater at Newport

Remedial investigation data (Woodward Clyde 1991) show manganese in site soils is 100 to 500 mg/kg in areas unimpacted by historic operations. The highest manganese levels were found in the South Landfill at levels of 4,000 mg/kg. Background levels for manganese in soil are 2 to 7,000 mg/kg (Shacklett 1984). Manganese is present in soils both on- and off-site.

Manganese is a site-related constituent due to its detection during the Remedial Investigation (Woodward Clyde 1991) at levels above EPA's 1 mg/L action level in monitoring wells both on- and off-site at levels from 0.04 mg/L to 10.6 mg/L (DERS 1993). Manganese continues to be present in long-term groundwater monitoring wells, at levels as high as high as 7 mg/L (wells which are not impacted by site activities [DuPont 2000]).

The presence of manganese in both on- and off-site soil and groundwater strongly suggest sources and mechanisms independent of historic site activities are primarily responsible for the observed phenomenon. In addition, the mere presence of manganese in soil does not create elevated levels in groundwater.

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As presented in Section 3.1.2, elevated manganese levels (>1mg/L) have been recently observed in South Landfill wells along the proposed perimeter of the reactive barrier.

3.3.2 Manganese Solubility

The solubility of manganese is primarily a function of its oxidation state and solution pH. Low redox conditions produce high levels of soluble manganese. Manganese can have two possible valences (+2 and +4) in solution. Only divalent manganese is soluble; the more oxidized forms form insoluble oxides. Stability diagrams (eH vs. pH) are frequently used to show the predominant elemental forms and complexes. Under conditions at the Newport site (see Figure 3), manganese is found in its highly soluble ionic form (Mn^{+2}).

The effect of the iron wall can be seen on Figure 3. The free oxygen and free hydrogen lines are the upper and lower boundaries in environmental (unconfined, atmospheric pressure) systems. The elemental iron line is below the hydrogen line. Consequently, elemental iron drives the eH low, ultimately producing hydrogen gas. (This is the effect which enhances dechlorination mechanisms in organic zero-valent iron systems.) This phenomenon was observed in the field tests-the eH in both treatment wells was lower than the controls (see table below).

Groundwater characteristics are shown on the table below.

Groundwater Characteristics in the Vicinity of the South Landfill			
ID	Manganese, mg/L	eH, Volts	pH, std units	Location
BC	1.7	-0.11	9.8	PRB Control Well - Old Airport Road
BT	13	-0.13	7.9	PRB Treatment Well - Old Airport Road
ZC	1.6	-0.13	7.3	PRB Control Well - Wetlands
ZT	0.5	-0.24	10.7	PRB Treatment Well - Wetlands
MW-23A	3.8	+0.28	6.4	Fill Zone Monitoring Well - Rte 141
PH and eH data were collected June 2000 Manganese in all wells except MW-23A sampled May and June, 2000 Manganese in MW-23A is Phase 3 RI - ~1991.			

These data are superimposed on Figure 3. The stability diagram shows that the soluble manganese is the predominant species in the vicinity of the South Landfill. Only in the ZT well, where the pH is 10.7 is the groundwater manganese level below the treatment standard of 1 mg/L.

Oxidation-reduction parameters are very difficult to measure precisely. The groundwater data shown above was gathered quickly and cannot be used to conclusively explain the observed phenomena. Its value is limited to suggesting the actual conditions impacting manganese solubility.

Since manganese is virtually ubiquitous, the mechanisms controlling manganese solubility are not known at this time. The incremental manganese observed in the test borings could be generated at the reactive barrier-soil interface, or be released from the zero-valent iron.

3.3.3 Manganese and the South Landfill Remedy

The stability diagram shows that the oxidation potential will be reduced as groundwater passes through a permeable reactive barrier containing iron. This phenomenon has been observed previously at other iron wall sites. At the South Landfill, the in situ treatment test borings indicate that manganese levels increase due to the presence of iron as groundwater passes through the reactive material (see BT vs. BC data above). The increase was not observed in the ZT:ZC pair because of the elevated pH in the ZT well.

At other sites employing iron walls, the reduced oxidation potential effect has dissipated quickly (within a few feet) as groundwater migrates from the barrier into a more oxidizing environment. Similarly at the South Landfill, groundwater conditions and mineralogy outside the barrier are expected to raise the oxidation state, creating conditions which should reverse the temporarily elevated manganese concentrations.

The RI data from MW-23A (and others, such as MW-9 and the Old Airport Road residences) provide a perspective on local background concentrations. That is, background manganese levels in the vicinity of the South Landfill may well be in excess of the treatment standard of 1 mg/L. These elevated levels are likely due to the influence of biological processes and the resulting reducing conditions associated with the wetlands which have existed for millennia.

While the data are very limited, background manganese concentrations may be a move appropriate performance standard than the treatment standard established in the ESD. Conditions outside of the landfill may not be oxidizing enough to reduce soluble manganese levels. Manganese in soils represents an infinite source of manganese which is continuously being released.

3.3.4 Additional Data

A focused assessment is needed to understand manganese transport in the vicinity of the South Landfill. The objective is to determine the likelihood that manganese levels can or will reach the treatment standard of 1 mg/L and establish a reasonable background manganese concentration.

Well transects will be installed to advance the understanding of the data collected to-date. Soil and groundwater will be studied to better understand the relationship between manganese and groundwater characteristics. A brief scope of work will be prepared describing the well locations and analytical design for approval by EPA.

The assessment will be complete by September 30, 2000.

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3.4 MONITORING TREATMENT EFFECTIVENESS

Monitoring wells placed inside the permeable reactive barrier will ensure treatment and provide an early warning to ensure protection of human health and the environment. Approximately 10 monitoring wells (on 200 ft centers) are proposed within the permeable reactive barrier. The wells will be installed in the outside 6 to 12 inches of the barrier. In addition, four sets of 3 wells each will be installed downgradient of the South Landfill to monitor manganese.

Installation of wells in the outer third of the permeable reactive barrier will monitor treatment conditions and metals capture. In addition, since laboratory and field tests show tens to hundreds of years wall life with 6- to 8-inch-diameter columns, placement of the wells in the outer third will provide adequate early warning, in the event breakthrough is occurring at some point in the future.

Wells outside the PRB will ensure that manganese levels return to acceptable levels as groundwater migrates from the landfill.

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The additional field explorations and evaluations conducted since the ESD support the implementation of permeable reactive barrier technology described in this proposal. DuPont believes that these modifications achieve the ROD-specified remedial action objectives (RAOs). This section describes how the PRB remedy achieves the RAOs and evaluates the ROD and ESD remedies as compared to the PRB remedy. The comparative evaluation will consider the following criteria specified in the National Oil and Hazardous Substance Pollution Contingency Plan:

- ❏ *Overall protection of human health and the environment*
- ❏ Compliance with ARARs
- ❏ Long-term effectiveness and permanence
- ❏ Reduction of toxicity, mobility, or volume through treatment
- ❏ Short-term effectiveness
- ❏ Implementability
- ❏ Cost
- ❏ State acceptance
- ❏ Community acceptance

4.1   ACHIEVEMENT OF REMEDIAL ACTION OBJECTIVES (RAOs)

The remedial alternatives in the ROD address contaminated soil, sediment, surface water, and groundwater at the Newport site. For the South Landfill, the objectives of the remedy are to prevent the following:

- ❏ Continued releases of contaminants to the groundwater that discharges to the river and the South Wetlands.
- ❏ Unacceptable human exposure to contaminated soil from the landfill.

The South Landfill remedy selected in the ROD consisted of the following elements to achieve the RAOs:

- ❏ Excavation and consolidation of contaminated soil underneath and to the east of Basin Road onto the South Landfill.
- ❏ In situ soil stabilization of the combined soil using deep-soil mixing technology.
- ❏ Capping of the South Landfill with a low permeability (1×10^{-5} cm/sec or less) cover.

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The ROD remedy was selected because it provided a high degree of overall protection of human health and the environment. Stabilization and capping would significantly reduce the ability of the contaminants in the South Landfill to migrate where they might contribute to exceeded groundwater maximum contaminant levels (MCL) and surface-water quality standards (SWQS). The cap would also prevent human exposure to contaminated soil from the landfill.

The ESD remedy consisted of the following elements to achieve the RAOs:

❑ In situ treatment of soil with chemical techniques described in Section 3.0.

❑ Soil-bentonite slurry wall, tied into the natural underlying silty clay zone, that circumscribes the waste in the South Landfill and Basin Road areas.

❑ An impermeable geomembrane cap over the South Landfill and Basin Road areas.

❑ Groundwater extraction to achieve an inward hydraulic gradient.

The ESD remedy was selected because it contained an upgraded containment system (dual barrier cap and circumscribing wall), met the criteria for selection significantly better, and was cost-effective, among others.

As an alternate to the ROD and ESD remedies, DuPont proposes a remedy that consists of the following elements to achieve the RAOs:

❑ A reactive barrier consisting of gypsum, zero-valent iron, and inert soil to treat and immobilize all fill-zone groundwater migrating from the landfill.

❑ A soil-bentonite slurry wall along the New Castle County sewer line, connecting with the PRB.

❑ A low permeability, single-barrier cap installed over the entire South Landfill and Basin Road areas. The caps will be tied into the roadway with an asphalt overlap.

❑ Geomembrane, soil and stone placed along the riverbank for isolation, erosion control, and vegetative restoration.

❑ Long-term monitoring to ensure the remedy is protective.

The proposed PRB remedy provides a higher degree of overall protection of human health and the environment than the alternates do. The PRB immobilizes barium and zinc, the migrating contaminants. Additionally, the soil-bentonite slurry wall, PRB, riverbank stabilization, and cap will isolate the waste, further reducing the potential for impact to surrounding groundwater, wetlands, and the river. The low-permeability cap will prevent human exposure to contaminated soil from the landfill and significantly reduce the potential for leaching by rainwater infiltration. The riverbank geomembrane and stone will contain waste outside of the slurry wall and prevent migration of contaminants to the river.

The proposed performance standards (see Section 5.3.2) will enhance the remedy's protectiveness. In the long term (as well as the short term), the PRB remedy is more protective of human health and the environment than the ROD or ESD remedies.

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4.2   NCP CRITERIA COMPARATIVE EVALUATION

4.2.1   Overall Protection of Human Health and the Environment

The ROD, ESD and PRB remedies provide a high degree of overall protection of human ..ealth and the environment. The ability of contaminants to migrate is significantly reduced by both stabilization and capping or treatment and containment. Both caps are equally effective in preventing human exposure to contaminated soil from the landfill. The low-permeability PRB cap will effectively reduce rainwater infiltration and the potential to leach contaminants from the waste, extending reactive wall life.

4.2.2   Compliance with ARARs

Most of the major ARARs for the South Landfill are related to the protection of wetlands, with the exception of Resource Conservation and Recovery Act (RCRA) Subtitle D closure requirements and Delaware Regulations Governing Solid Waste (see Table 12 of the ROD). All remedies meet their respective ARARs. Care will be taken during the design and construction to prevent any adverse effects in the South Wetlands and the Christina River. Riverbank stabilization ensures long-term containment of landfill material outside of the slurry wall and sewer line. Soil placed along with the stone will encourage rapid vegetation of the intertidal zone.

4.2.3   Long-term Effectiveness

The PRB remedy has increased long-term effectiveness when compared to the ROD because it chemically immobilizes the metals of concern, rather than merely reducing percolation (as stabilization would have). Stabilization is susceptible to fracturing because of differential settling that will create free pathways for unimpeded contaminant migration. The PRB remedy has better long-term effectiveness than the ESD because it is designed for long-term migration (hundreds of years) with materials that are either much less soluble (gypsum) or insoluble (iron). The ESD treatment agents were extremely soluble, hence susceptible to flushing from the waste by infiltration.

4.2.4   Reduction of Toxicity, Mobility, or Volume through Treatment

The ROD remedy reduced the mobility of metals through soil stabilization with a cement-type material that will increase the waste volume approximately 3 percent (15,000 cubic yards) (Kiber 2000). The ESD remedy reduced the mobility of metals by chemically locking (or by immobilizing) the soluble constituents onto the landfill as insoluble precipitates by an even larger (5 percent) volume increase (DuPont 1999). The PRB remedy also immobilizes migrating metals, however, no volume increase will occur. Hence, the PRB remedy is more effective than the ROD or ESD remedies for reducing mobility and volume.

4.2.5   Short-term Effectiveness

While all remedies are equally effective in the short term, the PRB remedy will be faster to implement because of its proven installation methods. The PRB remedy will not disturb the existing soil cover until the cap is installed. The ROD and ESD remedies will require two construction seasons for implementation, including over 50 weeks for the soil mixing. The PRB remedy will require one construction season to implement.

4.2.6   Implementability

The PRB technology is easier to implement than either stabilization or in situ chemical treatment. The same conventional trenching methods will be used to install both the slurry wall and PRB. DuPont has thoroughly evaluated the implementability of all three remedies and peer reviewed the methods with remedial contractors. Soil mixing is much slower and must cover the entire landfill, rather than just the circumference, even when multiple mixing units were considered.

The ROD remedy will also greatly restrict and possibly halt traffic along Basin Road during significant periods of time. The PRB remedy would only restrict traffic in one direction (or another) for only a few weeks.

4.2.7   Cost

The cost for the ROD, ESD and PRB remedies were investigated in detail. Additional treatability studies were performed to confirm the cost of the ROD remedy. The ESD remedy was re-designed with soil mixing and insoluble gypsum once the high chemical demand was quantified. The waste volume was confirmed to be approximately 500,000 cubic yards.

The table that follows summarizes the detailed cost estimates developed for the ROD, ESD, and PRB remedies (see Appendix C). The current cost estimate for the ROD remedy is $16MM. The cost estimate for the re-designed ESD remedy is $6MM (soil mixing, gypsum, and a single barrier cap). The estimate for the PRB remedy is $3MM.

COST COMPARISON ROD, ESD and PRB Remedies			
Item	ROD Remedy ($MM)	ESD Remedy ($MM)	PRB Remedy ($MM)
Site Preparation	0.2	0.2	0.2
Final Cover/Cap	0.4	1.3	1.3
Basin Road Excavation	1.5	0	0
Stabilization	9.8	0	0
Slurry (& PRB) Wall	0	0.2	0.6
Treatment	0	2.8	0
Cost Subtotal	11.9	4.5	2.1
Other Direct Costs	3.7	1.5	0.9
Construction Subtotal	15.6	6.0	3.0
Contingency (5%)	0.8	0.3	0.2
Total	16.4	6.3	3.2

4.2.8   State and Community Acceptance

DuPont expects that both the state and community will support the PRB remedy because of its cost-effectiveness and reduced impact on Basin Road traffic.

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4.3   SUMMARY OF COMPARATIVE EVALUATION

A summary of the comparative evaluation is provided in the table that follows. The PRB remedy is an innovative technology that significantly immobilizes the contaminants migrating from the South Landfill and ensures protection of human health and the environment. The PRB remedy meets the EPA's preference for treatment without increasing waste volume. While offering an improved level of protectiveness, significant cost savings will be realized.

SUMMARY OF COMPARATIVE EVALUATION			
Evaluation Criteria	In situ Stabilization (1993 ROD)	In situ Chemical Treatment and Containment (1995 ESD)	Permeable Reactive Barrier and Modified Cap (2000 Proposal)
RAOs	Meets RAOs	Meets RAOs	Meets RAOs
Overall Protection of Human Health and the Environment	Reduces waste permeability Cap prevents human exposure to waste	Immobilizes metals Isolates waste from environmental receptors Cap prevents human exposure to waste	Immobilizes migrating constituents Isolates waste from environmental receptors Cap prevents human exposure to waste
Compliance with ARARs	Meets ARARs	Meets ARARs	Meets ARARs
Long-term Effectiveness	Significantly decreases permeability of waste Leaching potential will increase with time	Chemically immobilizes metals Groundwater extracted to prevent migration to river or wetlands Waste permanently contained Rainwater infiltration minimized	Provides extended capacity for 100's of years of immobilization. Waste physically contained. Groundwater migration controlled. Rainwater infiltration minimized.
Reduction of Toxicity, Mobility, or Volume through Treatment	Significantly reduces permeability of waste Volume increase of 3 %	Immobilizes metals Volume increase of 5%	Immobilizes metals No volume increase
Short-term Effectiveness	Two year implementation	Two years to implement	One construction season to implement Never completely blocks traffic
Implementability	Soil mixing proven	Redesign with soil mixing proven	Proven methods. Less surface impact.
Cost	$16 million	$6 million	$3 million
State and Community Acceptance	Concerns raised during public comments	Likely supported	Likely supported

The PRB remedy is consistent with the criteria set forth in 40 CFR Part 300, Section 430(e)(9)(iii)—the National Contingency Plan—and was developed to ensure that this technology for the South Landfill is at least as protective of human health and the environment as the South Landfill remedy mandated in the ROD and ESD. The proposed performance standards are consistent with the remedy changes and eliminate standards that are no longer necessary. The performance standards for the elements of the South Landfill remedy that are not changed are not repeated in this section.

Sections 5.1 and 5.2 provide appropriate performance standards for the containment system that will physically separate the waste material and hydraulically control groundwater migration. The performance standards for the proposed soil-bentonite slurry wall (see Section 5.1) are taken from elsewhere in the ROD (Section 2.5—North Landfill Physical Barrier Wall) and EPA's prior decisions (EPA 1996a). The performance standards for the reactive barrier are proposed in Section 5.2. The performance standards for the modified cap (see Section 5.3) are taken from the ESD (Section 3.3—South Landfill Cap) and modified. Section 5.4 addresses additional performance standards which should be modified or deleted.

5.1   SOUTH LANDFILL SOIL-BENTONITE SLURRY WALL CONTAINMENT BARRIER

5.1.1   Remedy Description

A soil-bentonite slurry wall will be constructed from the ground surface and keyed into the aquitard that currently separates the waste material from the Columbia Formation sand. Figure 1 shows the approximate slurry wall location. The slurry wall will be installed in the locations along the river in the portion of the alignment within the waste and join the reactive section at each end in order to form a continuous barrier.

5.1.2   Performance Standards

The performance standards for the South Landfill soil-bentonite slurry wall containment barrier are as follows:

- ❑ A soil-bentonite slurry wall will be constructed to extend from the surface to 3 feet into the clayey silt layer below the waste. The slurry wall will be keyed into the reactive section to create a continuous barrier. The approximate slurry wall location is shown in Figure 1.

- ❑ The soil-bentonite slurry wall will be 3 feet wide and have a permeability of 1×10^{-7} cm/sec or less.

5.2   PERMEABLE REACTIVE BARRIER

5.2.1   Remedy Description

A permeable barrier, consisting of gypsum, zero-valent iron, and inert soil will be installed to immobilize all constituents of interest except manganese migrating from the site. The wall will be installed from the current landfill surface and keyed into the underlying marsh deposit.

5.2.2   Performance Standards

The performance standards for PRB treatment are as follows:

- ❏ A trench will be constructed which connects with the slurry wall in the areas outside of the landfill materials to create a circumscribing barrier which controls groundwater migrating from the landfill. The trench will be 3 feet wide and be keyed into the underlying marsh deposit.

- ❏ The trench will be filled with reactive agents and sand in a 100:20:5 weight ratio of sand: gypsum: iron.

- ❏ Approximately ten (10) monitoring wells will be installed in the reactive barrier on 200-foot centers. The wells will be screened across the entire reactive zone.

- ❏ The monitoring wells will be sampled for the constituents of concern (barium, lead, zinc, cadmium, manganese, copper and nickel) and iron on a monthly frequency for one year and quarterly thereafter. Field measurements of pH, eH, and dissolved oxygen will also be performed.

5.3   SOUTH LANDFILL CAP

5.3.1   Remedy Description

A multilayer cap with a permeability of 1×10^{-7} cm/sec or less will be installed over the South Landfill. The cap will include a geomembrane, protective soil, and topsoil, as shown in Figure 2.

5.3.2   Performance Standards

The performance standards for the South Landfill cap are as follows:

- ❏ Prior to clearing and grubbing, 32 work-hours will be spent collecting and moving to a new, similar environment any wildlife that is residing in areas to be affected by the remediation.

- ❏ A landfill cap will be installed that completely covers the portion of the South Landfill with the exception of Basin Road. The engineering design will incorporate the road into the cap design.

- ❏ The landfill cap will be designed and constructed in such a way as to limit, to the maximum extent practical, any encroachment on the South Wetlands or the Christina River.

- ❏ The landfill cap will incorporate a single barrier layer and have a maximum permeability of 1×10^{-7} cm/sec or less.

- ❏ The landfill cap will be designed and constructed to function with minimum maintenance; to promote drainage and minimize erosion or abrasion of the cover; and to accommodate settling so that the cover's integrity is maintained.

- ❏ The landfill cap will be revegetated in such a way as to provide a high-quality wildlife habitat, to the maximum extent practical, without attracting burrowing animals that could endanger the low-permeability layer. The types of vegetation will be identified in the remedial design.

- ❏ A cap for the intertidal riverbank area will consist of geosynthetic membrane, stone and soil to control erosion and isolate the river from the landfill.

5.4   ADDITIONAL PERFORMANCE STANDARDS TO BE MODIFIED OR DELETED

With the selection of the PRB remedy, the following performance standards can be modified while continuing to ensure protection of human health and the environment.

3.3.8	Modify to allow cap to tie into Basin Road and not be constructed under the road.
3.3.9	Modify to allow geocomposite clay liner.
3.6.1	Modify to allow PRB section and groundwater migration.

With the selection of the PRB remedy, the following performance standards are no longer needed.

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3.8.1	Specifies sodium sulfate and sodium sulfide to treat waste material.
3.8.2	Specifies use of a "no-till subsoiler" for application of treatment materials.
3.8.3	Specifies a irrigation to supplement rainfall.
3.8.4	Specifies containment of infiltration water.
3.8.6	Specifies treatment to continue until excess treatment ions are observed in monitoring wells.
3.8.7	Specifies treatment extent.
3.8.8	Specifies air monitoring for hydrogen sulfide odors.
3.8.9	Specifies calculation of theoretical agent demand.
3.3.10	Specifies cap to be constructed under Basin Road.
3.7.1 through 3.7.5	Specifies groundwater pump and treat system.

In addition, other standards may need minor modification or further discussion with EPA to ensure the remedy is consistent with the performance standards and vice versa.

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6.1   CONCLUSIONS

The PRB remedy, consisting of a permeable reactive and slurry wall, riverbank stabilization with geomembrane, single barrier cap, and monitoring, meets all nine NCP selection criteria and is a superior alternative to both the ROD and ESD remedies.

6.2   RECOMMENDATIONS

DuPont recommends conditional approval of the conceptual design presented in this report. Approval is conditional on DuPont's demonstration that manganese levels in groundwater migrating from the wall are reduced by sub-surface conditions to background levels. Water will "reequilibrate" with natural conditions in the aquifer downgradient of the wall i.e., background levels.

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The authors would like to express their appreciation for the untiring commitment to the success of this project made by Dr. Noel C. Scrivner from DuPont Engineering Technology (DuET), Mr. William B. Bazela of the Process Development Group of DuPont Corporate Research and Development, and Mr. William R. Kahl of the W-C Diamond Group.

Analytical services were provided by Dr. Jane Ramsey and Mr. Mark McElwee of the DuPont Corporate Center for Analytical Services. Additional analytical services were coordinated by Mr. Mike Aucoin of the W-C Diamond Group.

Mr. Robert Semenak of Kiber Environmental Services lead the stabilization and permeability assessment work.

Field support was provided by Mr. Michael Dowger of the URS Corporation and Mr. Thomas Morgan of the W-C Diamond Group.

Without their teamwork and energy, this alternative solution would never have been developed.

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LEGEND

VE & PQ TEST PIT LOCATIONS

WASTE BORING LOCATIONS-12/94

GEOPROBE LOCATIONS- 2/00

TEST HOLE LOCATION-3/93

MONITORING WELL

NEW CASTLE COUNTY SEWER MAIN

SLURRY WALL

PERMEABLE REACTIVE WALL

LIMITS OF WASTE
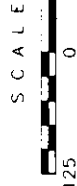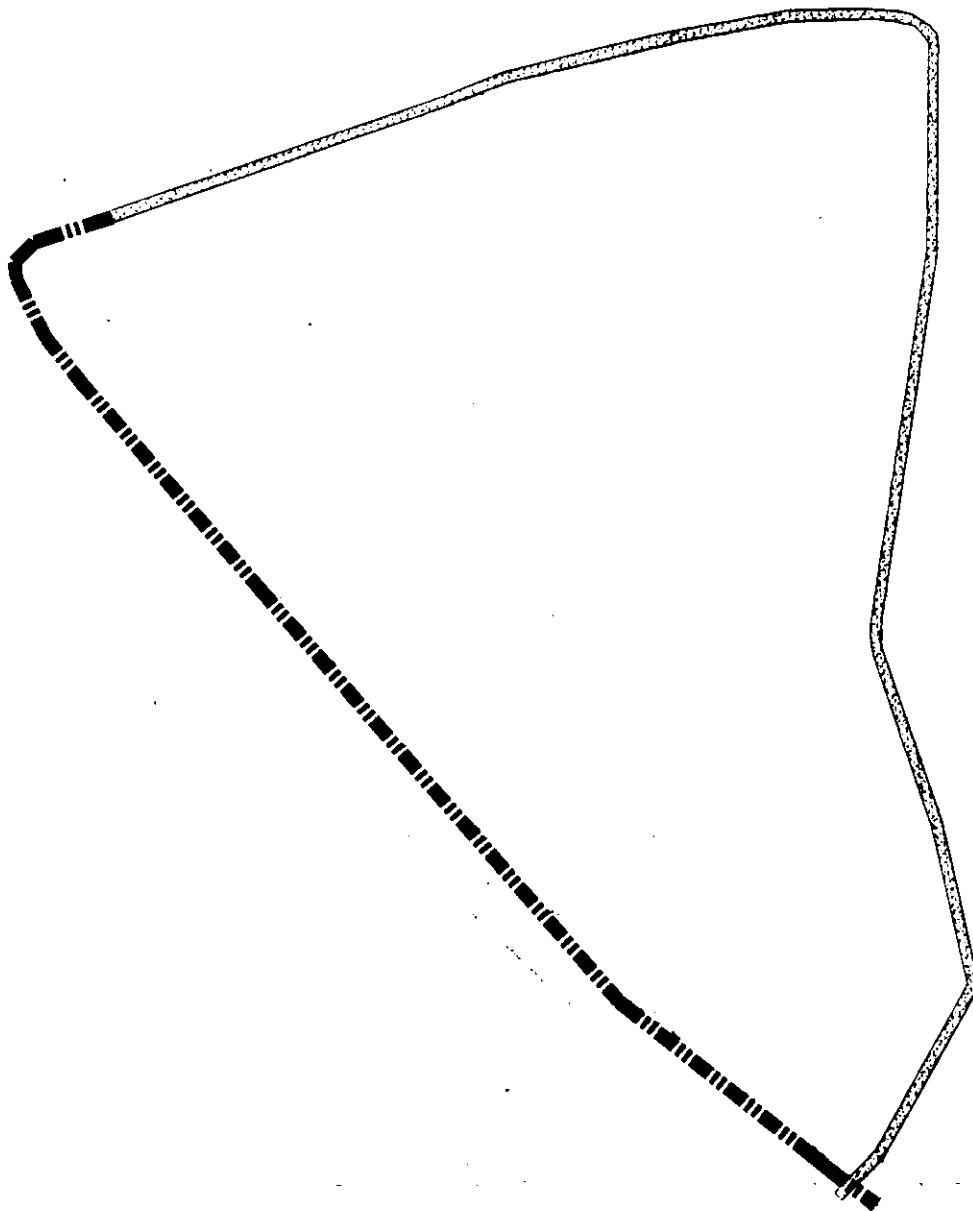
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PERMEABLE REACTIVE
BARRIER AND SLURRY WALL
SOUTH LANDFILL
NEWPORT SUPERFUND SITE
NEWPORT, DELAWARE
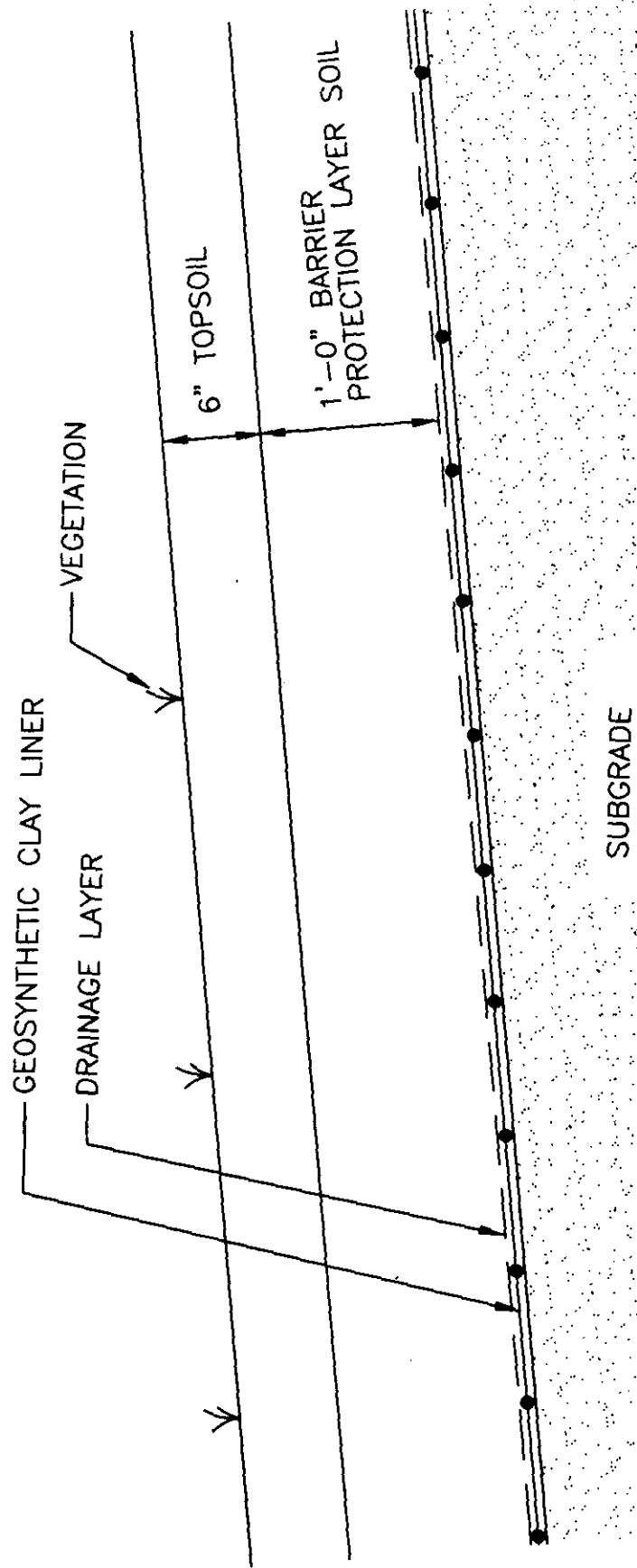
SCALE

125   0   125 FEET

VEGETATION

6" TOPSOIL

1'-0" BARRIER
PROTECTION LAYER SOIL

GEOSYNTHETIC CLAY LINER

DRAINAGE LAYER

SUBGRADE

CONCEPTUAL CAP DESIGN

SOUTH LANDFILL
NEWPORT SUPERFUND SITE

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SCALE	NTS	DESIGNED	DRAWN		
DATE	7/6/00	CHECKED	APPROVED	SHEET	2

Figure 3
Manganese Stability Diagram
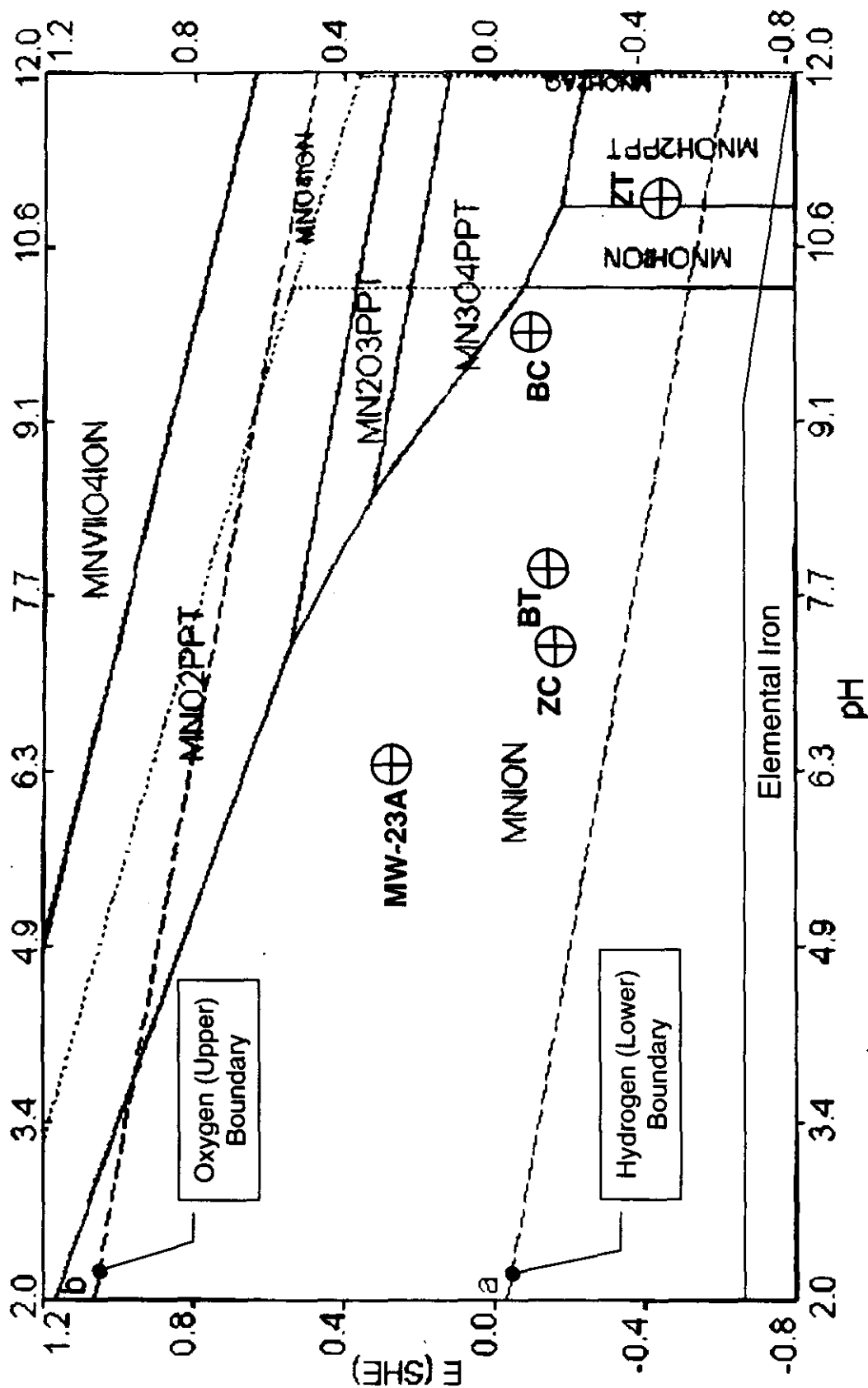
APPENDIXES

APPENDIX A

June 28, 2000

To: P. Brandt Butler
      CRG/WCD

From: John A. Wilkens
      CR&D

Newport South Landfill:
Laboratory Development of Data for a
Permeable Reactive Wall

Permeable Reactive Wall -- Developmental Basis

A permeable reactive wall (PRW), a.k.a. permeable reactive barrier, is an underground emplacement of reactive material in the path of flowing groundwater, such that aqueous contaminants are removed or destroyed as groundwater passes through the wall. Many metals can be removed by precipitation or sorption. Such a wall would be two- to three-feet thick, and deep enough to key into impermeable clay layers at the base of an aquifer. It would circumscribe the South Landfill except in the area where there would be a barrier slurry wall. Once emplaced, a wall requires virtually no routine maintenance, just monitoring of the external groundwater for performance confirmation.

To determine whether PRW technology would work for barium and zinc removal from the Newport South Landfill, a series of batch and column experiments was performed in the laboratory. First, scouting batch tests were made to see what materials had the capability to remove the metals. Two materials, gypsum ($CaSO_4.2H_2O$) and zero-valent iron showed excellent removal properties for barium and zinc, respectively. These were then used in continuous-flow column tests to demonstrate their effectiveness together and with the sand that would make up the bulk of the PRW. Wall life projections were then made based on the column tests and flows through the PRW under assumptions of different landfill cap configurations.

As a final technology demonstration, we employed a significant new in-situ field test that has been demonstrated by the U.S. EPA and DuPont. A 12-inch diameter column of the PRW sand:gypsum:ZVI mix was emplaced in the ground in the presence of contaminated groundwater. Central in the column was a one-inch monitoring well. Performance was determined by sampling the core water that had passed through six inches of reactive material. The results of this test further validate the laboratory projections.

Laboratory Batch Tests -- Procedures

Batch tests were employed for screening reactive materials for use in a Permeable Reactive Wall. Two types of water were tested, representing areas of high barium or zinc concentration. Appropriate materials were used for each removal action:

- ➤ Water from a barium-rich zone within the South Landfill
  - ▪ Material: $CaSO_4.2H_2O$ (gypsum)
- ➤ Water from a zinc-rich zone within the South Landfill
  - ▪ Materials: Zero-valent iron, millscale, steel slag, iron sulfide

These tests covered a broad range of concentrations for each reactive material, to determine the level at which each would potentially become effective. Reaction times were standardized at 24 hours; experience with kinetics experiments showed that this was a good measure of relative performance. Groundwater and materials were put in 125 cc polypropylene bottles, the headspace purged with nitrogen, and then agitated end-over-end for 24 hours. Samples of the liquid phase were then passed through a 0.45-micron filter and analyzed for the constituents of interest. Control samples followed the same procedures except that no material was added.

Analytical Procedures

Sample analyses were performed by DuPont's Corporate Center for Analytical Sciences:

- ➤ Barium and zinc were analyzed using ICP-AES (inductively coupled plasma -- atomic emission spectroscopy) down to 100 ppb and 25 ppb, respectively.
- ➤ Other metal concentrations were determined using ICP-MS to the following levels (ppb): aluminum 100, cadmium 4, calcium 100, copper 4, iron 100, lead 4, magnesium 100, manganese 100, nickel 100, potassium 100, and sodium 100.
- ➤ Anion concentrations were determined using IC (ion chromatography) down to 500 ppb: sulfate, chloride, fluoride, nitrate, nitrite, and phosphate.

Laboratory Batch Tests -- Results

Barium concentrations were reduced from 290,000 ppb to less than 500 ppb by the addition of 0.5 weight percent of $CaSO_4.2H_2O$, through the precipitation of $BaSO_4$. This was substantially lower than the required 7,800 ppb standard. Additional gypsum concentrations decreased barium levels to a minimum of approximately 150 ppb; illustrative results are shown in the following table:

Wt. % CaSO₄.2H₂O	Barium conc., ppb
0	290,000
.5	492
1	416
4	224
9	177
29	143

Zinc concentrations were readily reduced from approximately 1000 ppb to less than 10 ppb (vs. a goal of 120 ppb) by several materials, including zero-valent iron (Peerless -8 +50 mesh), iron sulfide, steel-process mill scale, and steel slag, with the first two showing exceptional activity. Zero-valent iron, used as a PRW additive for chromium removal and dechlorination of organics, performed very well for zinc removal. The mechanism is not the cementation as in copper removal, but is probably sorption onto hydrous iron oxides surfaces. The performance of zero-valent iron is shown in the table below:

Wt. % ZVI	Zinc conc., ppb
0	1020
.5	38
1	39
2 and higher	<10

Of the other metals of concern, cadmium, copper and lead were less than the detection limits of 4 ppb in both feeds and treated waters. Nickel was less than the goal of 73 ppb in feeds and all treated waters, and was reduced in all cases except mill scale. Manganese was generally not reduced by the materials, and in some cases showed increases, although below the limit of 1000 ppb.

Laboratory run sheets follow for the independent batch experiments with gypsum for barium removal and zero-valent iron for zinc removal. They give full details of the experimental conditions and the concentrations of metals found at all levels of gypsum and ZVI addition.

Newport South Landfill -- Groundwater Ba Removal -- CaSO4

Bottle vol (cc)= 125
Material mix density (g/cc) = 2.32
Mix wt. Fract. ABC = 0.000
Mix wt. Fract. XYZ = 1.000

Component XYZ: CaSO4

Calculation Date: 1/14/2000   By: JAW
Lab Prep Date: 1/17/2000   By: WBB
Notebook Number -- Page: E98123-32

Target

Wt. Rto Mx/Wtr	Wt % Mix	Wt. Mix g	Vol. Mix cc	Vol. Wtr cc	Total Vol cc
0.000	0.00	0.00	0.00	125.00	125
0.005	0.50	0.62	0.27	124.73	125
0.010	0.99	1.24	0.54	124.46	125
0.020	1.96	2.48	1.07	123.93	125
0.040	3.85	4.92	2.12	122.88	125
0.080	7.41	9.67	4.17	120.83	125
0.100	9.09	11.98	5.17	119.83	125
0.200	16.67	23.02	9.92	115.08	125
0.330	24.81	36.11	15.57	109.43	125
0.400	28.57	42.65	18.38	106.62	125

Laboratory Run

Smpl No.	Wt. ABC Target g	Wt. ABC Actual g	Wt. Xyz Target g	Wt. Xyz Actual g	Wt. Water Target g	Wt. Water Actual g	pH at End of Run Meter	pH at End of Run Paper
1	0.00	0.00	0.000	0.00	125.00	125.00	10.1	10.0
2	0.00	0.00	0.624	0.63	124.73	124.70	11.1	10.0
3	0.00	0.00	1.245	1.24	124.46	124.40	10.3	10.5
4	0.00	0.00	2.479	2.49	123.93	123.90	10.3	10.5
5	0.00	0.00	4.915	4.92	122.88	122.80	10.5	10.5
6	0.00	0.00	9.667	9.67	120.83	121.00	10.5	10.5
7	0.00	0.00	11.983	11.98	119.83	119.80	10.5	10.5
8	0.00	0.00	23.016	23.02	115.08	115.00	10.5	10.5
9	0.00	0.00	36.113	36.12	109.43	109.40	10.7	10.5
10	0.00	0.00	42.647	42.67	106.62	106.60	10.6	10.5

WHERE:

Wt. Ratio, Mix / Water	g/g	Input data
Wt of Matl mix	g	= Botvol * RhoM / (1+RhoM / (Ratio*RhoW))
Wt. CaSO4	g	= Wt Mix * Mix wt. Fract. CaSO4
Wt. Xyz	g	= Wt Mix * Mix wt. Fract. Xyz
Wt. Water	g	= Wt Mix / Wt. Ratio
Vol of Matl Mix	cc	= Wt Mix / Mix Density
Vol of Water	cc	= Wt Water / Density of water
Total Vol	cc	= Vol Mix + Vol Water

Notes:

"Water" is Newport South Landfill RDW-2 groundwater, used unfiltered in the experiments.

Samples for analytical filtered through 0.45 um filter

"CaSO4" is CaSO4.2H2O from ISG Resources (DuPont, Richmond)

Tumbler contact time = 24 hours for all samples

Sample 1 is a control; the formulas do not apply.

J. A. Wilkens, W. B. Bazela

AR324400

Newport South Landfill -- Groundwater Ba Removal -- CaSO4
Run Summary -- p.2

Calculation Date: 1/14/2000
Lab Prep Date: 1/17/2000

Notebook Number -- Page: E98123-32
Component XYZ: CaSO4

Results after Treatment

Smpl No.	Wt.CaCO3 per Wt. H2O	Wt. XYZ per Wt. H2)	pH at End of Run Meter	pH at End of Run Paper	Sulfate	Chloride	Fluoride	Nitrate	Nitrite	Phosphate
1	0.00	125.00	10.1	10.0	2,000	13,000	4,000	500	500	296
2	0.0000	0.0050	11.1	10.0	1,463,000	14,000	1,000	500	500	374
3	0.0000	0.0100	10.3	10.5	1,524,000	13,000	1,000	500	500	424
4	0.0000	0.0201	10.3	10.5	1,529,000	13,000	1,000	500	500	485
5	0.0000	0.0401	10.5	10.5	1,539,000	14,000	1,000	500	500	485
6	0.0000	0.0799	10.5	10.5	1,504,000	14,000	1,000	500	500	485
7	0.0000	0.1000	10.5	10.5	1,549,000	15,000	1,000	500	500	471
8	0.0000	0.2002	10.5	10.5	1,573,000	16,000	1,000	500	500	482
9	0.0000	0.3301	10.7	10.5	1,667,000	20,000	1,000	500	500	496
10	0.0000	0.4003	10.6	10.5	1,607,000	20,000	1,000	500	500	506

Metal Concentrations, ppb

Smpl No.	Ba	Zn	Al	Cd	Ca	Cu	Fe	Pb	Mg	Mn	Ni	K	Na
1	290,000	25	10	4	4,680	4	10	4	335	10	10	42,400	8,280
2	492	25	10	4	766,000	4	2,038	4	284	10	17	41,400	8,730
3	416	25	10	4	791,000	4	2,048	4	281	10	17	42,900	9,090
4	193	25	10	4	760,000	4	1,981	4	248	10	16	44,100	9,580
5	224	25	10	4	735,000	4	1,954	4	234	10	18	49,800	11,100
6	174	25	10	4	717,000	4	1,862	4	190	10	17	60,600	13,500
7	177	25	10	4	690,000	4	1,811	4	157	10	17	62,600	14,000
8	157	25	10	4	677,000	4	1,760	4	119	10	18	88,300	19,400
9	146	25	10	4	701,000	4	1,804	4	89	10	20	129,000	28,100
10	143	25	10	4	688,000	4	1,729	4	101	10	20	148,000	32,200

J. A. Wilkens, W. B. Bazela

AR324401

Newport South Landfill -- Groundwater Zn Removal -- Peerless -8 +50 ETI Std

Component XYZ: **Peerless -8 +50 ETI Std**

Bottle vol (cc)= 125
Material mix density (g/cc) = 7.00
Mix wt. Fract. CaSO4 = 0.000
Mix wt. Fract. XYZ = 1.000

Calculation Date: 1/17/2000 By: JAW
Lab Prep Date: 1/1/1900 By: WBB
Notebook Number -- Page: E98123-35

| Target | | | | | | Smpl | Laboratory Run | | | | | | | | |
Wt Rto MxWtr	Wt % Mix	Wt. Mix g	Vol. Mix cc	Vol Wtr cc	Total Vol cc	No.	Wt. CaSO4 Target g	Actual g	Wt. Xyz Target g	Actual g	Wt. Water Target g	Actual g	pH at End of Run Meter	Paper
0.000	0.00	0.00	0.00	125.00	125	1	0.00	0.00	0.000	0.00	125.00	125.00	7.0	7.0
0.005	0.50	0.62	0.09	124.91	125	2	0.00	0.00	0.625	0.625	124.91	124.90	7.4	7.0
0.010	0.99	1.25	0.18	124.82	125	3	0.00	0.00	1.248	1.248	124.82	124.80	7.5	7.0
0.020	1.96	2.49	0.36	124.64	125	4	0.00	0.00	2.493	2.493	124.64	124.60	7.4	7.0
0.040	3.85	4.97	0.71	124.29	125	5	0.00	0.00	4.972	4.923	124.29	124.30	7.8	7.5
0.080	7.41	9.89	1.41	123.59	125	6	0.00	0.00	9.887	9.889	123.59	123.60	8.5	8.0
0.100	9.09	12.32	1.76	123.24	125	7	0.00	0.00	12.324	12.327	123.24	123.20	8.5	8.0
0.200	16.67	24.31	3.47	121.53	125	8	0.00	0.00	24.306	24.306	121.53	121.50	8.9	8.0
0.330	24.81	39.39	5.63	119.37	125	9	0.00	0.00	39.393	35.956	119.37	119.80	9.1	8.0
0.400	28.57	47.30	6.76	118.24	125	10	0.00	0.00	47.297	47.297	118.24	118.20	9.4	8.0

Data Updated: 2/4/2000

WHERE:

Wt. Ratio, Mix / Water	g/g	input data
Wt of Matl mix	g	= Botvol * RhoM / (1+RhoM / (Ratio*RhoW))
Wt. CaSO4	g	= Wt Mix * Mix wt. Fract. CaSO4
Wt. Xyz	g	= Wt Mix * Mix wt. Fract. Xyz
Wt. Water	g	= Wt Mix / Wt. Ratio
Vol of Matl Mix	cc	= Wt Mix / Mix Density
Vol of Water	cc	= Wt Water / Density of water
Total Vol	cc	= Vol Mix + Vol Water

Notes:

"Water" is Newport South Landfill RDW-1 groundwater, used unfiltered in the experiments.
Peerless Cast Iron -8 +50 mesh (ETI Standard)
"CaSO4" is CaSO4.2H2O from ISG Resources (DuPont, Richmond)
Reaction bottle headspace: Nitrogen
Tumbler contact time = 24 hours for all samples
Samples for analytical filtered through 0.45 um filter
Sample 1 is a control; the formulas do not apply.

J. A. Wilkens, W. B. Bazela

Newport South Landfill -- Groundwater Zn Removal -- Peerless -8 +50 ETI Std
Run Summary -- p.2

Calculation Date: 1/17/2000 Notebook Number -- Page: E98123-35
Lab Prep Date: 1/1/1900 Component XYZ: Peerless -8 +50 ETI Std

Results after Treatment

Smpl No.	Wt.CaCO3 per Wt. H2O	Wt. XYZ per Wt. H2)	pH at End of Run Meter	pH at End of Run Paper	Sulfate	Chloride	Fluoride	Nitrate	Nitrite	Phosphate
1	0.00	125.00	7	7	500	87,000	500	500	5,000	500
2	0.0000	0.0050	7	7	500	88,000	500	500	5,000	500
3	0.0000	0.0100	8	7	1,000	87,000	500	500	5,000	500
4	0.0000	0.0200	7	7	1,000	88,000	500	500	4,000	500
5	0.0000	0.0396	8	8	1,000	88,000	500	500	4,000	500
6	0.0000	0.0800	9	8	1,000	90,000	500	500	3,000	500
7	0.0000	0.1001	9	8	1,000	90,000	500	500	2,000	500
8	0.0000	0.2000	9	8	1,000	92,000	500	500	2,000	500
9	0.0000	0.3001	9	8	1,000	96,000	500	500	1,000	500
10	0.0000	0.4001	9	8	1,000	97,000	500	500	6,000	500

Column group: Anion Concentrations, ppb = Sulfate, Chloride, Fluoride, Nitrate, Nitrite, Phosphate

Metal Concentrations, ppb

Smpl No.	Ba	Zn	Al	Cd	Ca	Cu	Fe	Pb	Mg	Mn	Ni	K	Na
1	83,900	1,020	60	4	82,900	4	196	4	18,900	487	25	55,100	58,200
2	78,800	38	10	4	81,200	4	39,700	4	19,500	812	11	56,100	60,100
3	81,000	39	10	4	79,600	4	40,800	4	17,800	999	11	54,300	55,000
4	80,000	10	10	4	81,000	4	31,100	4	19,300	893	11	5,900	59,800
5	76,700	10	10	4	83,900	4	3,920	4	18,700	342	11	6,080	60,200
6	61,800	10	10	4	68,500	4	800	4	17,100	40	11	6,470	59,300
7	55,600	10	10	4	40,000	4	547	4	15,300	61	11	6,810	59,700
8	38,100	10	10	4	25,200	4	51	4	11,300	26	11	8,020	59,900
9	17,400	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
10	27,900	10	10	4	20,200	4	10	4	4,130	10	11	9,280	58,600

J. A. Wilkens, W. B. Bazela   Data Rev: 2/4/2000

Laboratory Column Tests - Procedures

Continuous-flow column tests were then run to determine the performance over time of a proposed reactive wall mix on the South Landfill groundwater. Two independent tests were run, on barium-rich and zinc-rich waters. These waters were taken from the highest-concentration wells for barium and zinc in the current field sampling, and differed from the sources (no longer available) used for the batch tests.

A standard Delaware Department of Transportation material, mason sand, was chosen as the base material for the PRW. From permeability data (developed by Kiber Environmental), it was determined that 20 weight percent gypsum could be mixed with the mason sand and maintain a permeability (6×10^{-4} cm/sec). This is greater than that of the landfill material, and thus will permit flow of groundwater out of the landfill. The composition of groundwater leaving the landfill at any point is not known with certainty, so that it is not possible to delineate zinc-removal and barium-removal portions of the PRW. Consequently, one wall composition was chosen to accommodate both the worst-case barium and zinc levels. Based on the batch tests and a projection of reactant needs, a mix composition was chosen with parts by weight of:

Sand : Gypsum : ZVI = 100 : 20 : 5.

For the laboratory experiments two independent column tests were run concurrently, one with barium-rich feed water and one with zinc-rich feed water. The supply reservoirs were nitrogen blanketed with a positive-flow purge. Each test consisted of a reactive column filled with the above mix, and a control column filled with sand alone. The vertical Lucite® columns were 2-inches inside diameter. Reactive sections were eight inches long, with one inch of pure sand above and below the mix, and glass wool at the entrance and exit. The control columns contained ten inches of sand. An upward flow of groundwater was maintained at 500 cc/day through each column using low-flow peristaltic pumps, giving a throughput of four active void volumes per day.

Flow pressure drops across the reactive columns were measured to determine the permeability of the columns, and to project whether there would be a decrease in permeability as a PRW ages. For this, pressures were measured at the entrance and exit points of the reactive sections by independent manometers. This arrangement is illustrated in the drawing that follows.

Laboratory Column Tests -- Apparatus
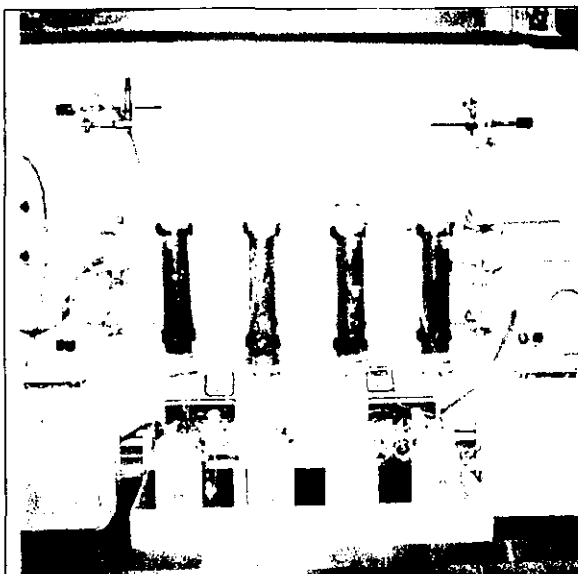
Overview of column apparatus, showing two independent, concurrent tests. Left (zinc-rich) water reservoir fed left two columns, right (barium-rich) reservoir fed right two columns.
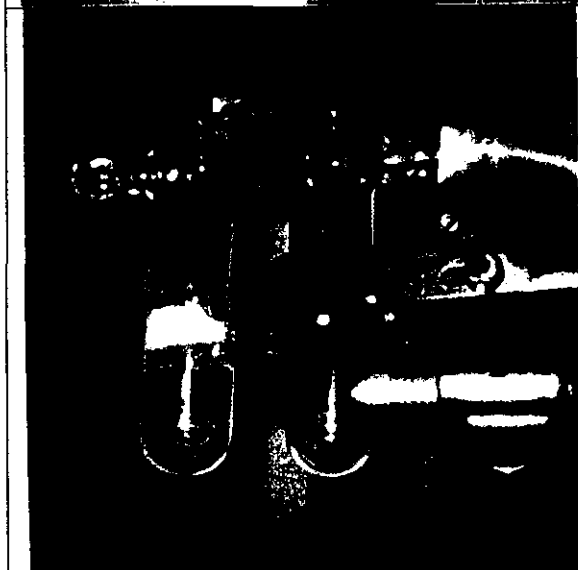
Nitrogen blanket over feed reservoirs was maintained by continuous low flow and exit bubblers filled with mineral oil.
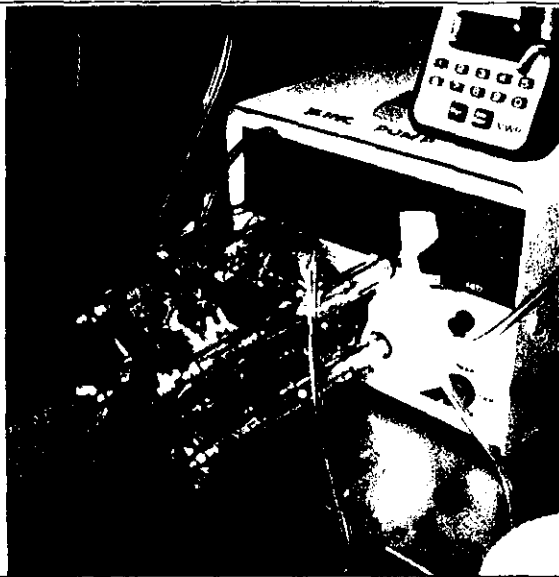
The feed flow to each (Ba, Zn) system was maintained by a peristaltic pump with low-flow heads. A rate of 500 cc/day/column gave four reactive void volumes of flow per day.
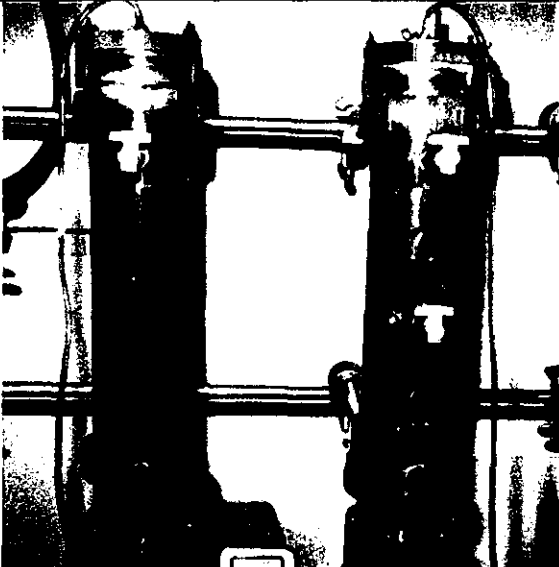
Zinc columns, with the reactive unit on the right. Eight inches of reactive mix was preceded and followed by one inch of pure sand. Plastic mesh spacers separated reactive mixes from pure sand, and glass wool was used at the inlets and outlets. For the control column, a sand bed 10 inches deep was used. A small amount of the gypsum formed small balls, seen as white spots, while most was uniformly dispersed throughout the column.
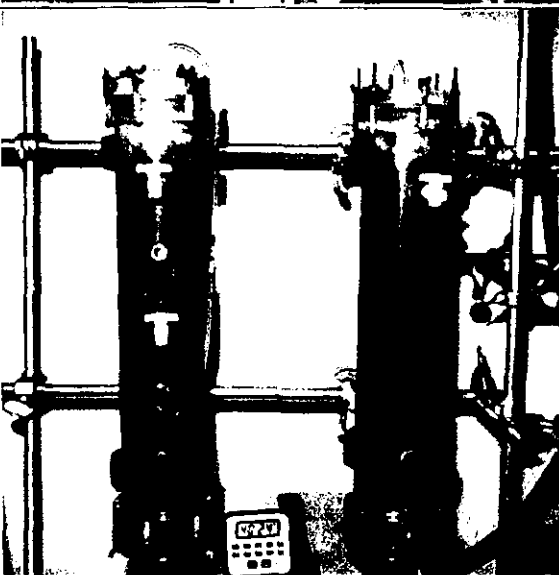
Barium columns quickly turned dark gray in operation; the water gave off a strong sulfide odor. Manometer tubes were later inserted in the upper and lower ports of the reactive columns to determine the pressure drop across the reactive bed.

Newport South Landfill Column Test

Column Pressure Drop Measurements
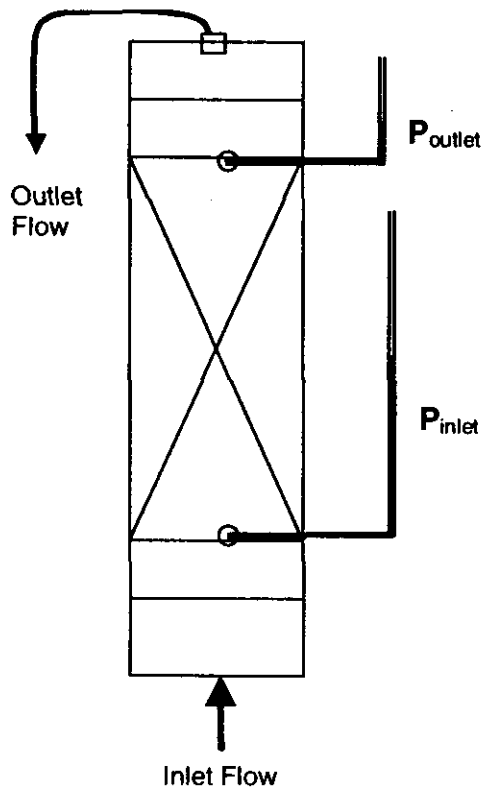
Pressure drop across column
$$= P_{inlet} - P_{outlet}$$

NOTES:

➤ Independent water manometers were used for pressure measurements at inlet and outlet taps
➤ Outlet flow is at the level of P_{outlet}
➤ Distance between P_{outlet} and P_{inlet} = 8 inches
➤ Sand beds: 8 inches of reactive bed, with 1 inch of sand above and below reactive section
➤ Inlet and outlet taps are within sand beds, as close as possible to the beginning and end of reactive sections

Laboratory Column Tests -- Results

Barium removal was readily accomplished from both the barium-rich and zinc-rich groundwaters. With the barium-rich feed, 500,000 ppb Ba was reduced to 1,000 ppb. With the zinc-rich feed, 70,000 ppb Ba was reduced to 100 ppb. These results were consistent over the one-month test, and demonstrate barium removal to well less than the 7,800 ppb limit.

Zinc removal was difficult to quantify due to analytical complexities (possible interferences, etc.), but the performance was clear. The zinc-rich water feed varied erratically from 100 to 1000 ppb Zn. Regardless of the input level, the zinc was consistently reduced to non-detect (25 ppb) in both the active and control columns over the one-month test. Thus zinc levels were well below the standard of 120 ppb. With the barium-rich feed water, no zinc was detected in the feed or effluent streams. This was consistent with the strong sulfide odor of this water, which implied that zinc had been precipitated in-situ as the sulfide.

Of the other metals of concern, like with the batch tests, cadmium, copper and lead were less than the detection level of 4 ppb in both feeds and treated waters. Nickel, at about 10 ppb in feeds, was less than 30 ppb in effluents, well below the goal of 73 ppb. Manganese, up to 0.1 ppm in feeds, was observed in zinc water column effluents at 0.2 to 8 ppm, and in barium water column effluents at 0.2 ppm to non-detect (10 ppb).

Reactive column flow pressure drops were used to calculate the column material permeabilities after 45 days of flow. The hydraulic conductivities were 2.2 x 10^{-4} and 2.6 x 10^{-4} cm/sec for the zinc and barium columns, respectively, the same magnitude as the fresh mixture tested by Kiber Environmental, ~6 x 10^{-4} cm/sec. No permeability decrease was thus observed over many simulated wall lifetimes, and wall plugging should not occur.

Data sheets follow which show the progress through the continuous column tests. First is a table of the results from the zinc-rich water test, then one for the independent barium-rich water test. These follow zinc and barium removal, for which analysis was regularly done. Third is a pair of tables showing the full scan of metals analysis, which was done for a few days.

Newport South Landfill
Barium and Zinc Removal Column Tests

Date	Run Day		Zinc Water Columns (from well RDW-1)					
			Feed		Control		Reactive	
			Ba ppb	Zn ppb	Ba ppb	Zn ppb	Ba ppb	Zn ppb
3-18	2		70,500	nr	4,830	nr	640	nr
3-19	3		68,500	nr	29,300	nr	480	nr
3-20	4		72,500	nr	53,500	nr	453	nr
3-21	5		70,000	nr	59,000	nr	nr	nr
3-22	6		74,600	168	61,800	nd	114	nd
3-23	7		74,600	158	64,000	nd	nr	nd
3-24	8		68,000	827	94,700	nd	183	nd
3-25	9		72,500	1,710	70,000	nd	109	nd
3-26	10		71,500	950	66,400	nd	113	nd
3-27	11		74,600	368	62,100	nd	87	nd
3-28	12		71,800	195	56,100	nd	173	nd
3-30	14		72,400	926	56,100	nd	173	nd
3-31	15		79,300	966	62,200	nd	91	nd
4-3	18		55,200	1,050	73,000	nd	96	nd
4-5	20		54,000	540	53,000	nd	80	nd
4-7	22		49,400	67	44,600	nd	133	nd
4-10	25		54,400	358	55,000	nd	66	nd
4-12	26		56,800	163	52,400	nd	48	nd
4-14	29		70,500	57	52,700	nd	<100	nd

KEY:

Feed = Supply reservoir for both Control and Reactive Columns

Control = Exit (top) concentration from column filled with 100% sand

Reactive = Exit (top) concentration from column filled with reactive materials in sand

nd = non-detect (25 ppb) for zinc

nr = no meaningful analytical result

Newport South Landfill
Barium and Zinc Removal Column Tests

Date	Run Day	Barium Water Columns (from well RDW-2)					
		Feed		Control		Reactive	
		Ba ppb	Zn ppb	Ba ppb	Zn ppb	Ba ppb	Zn ppb
3-18	2	496,000	nd	214,000	nd	1,110	nd
3-19	3	518,000	nd	473,000	nd	1,100	nd
3-20	4	551,000	nd	509,000	nd	800	nd
3-21	5	601,000	nd	464,000	nd	1,000	nd
3-22	6	600,000	nd	564,000	nd	328	nd
3-23	7	417,000	nd	475,000	nd	344	nd
3-24	8	293,000	nd	281,000	nd	446	nd
3-25	9	421,000	nd	418,000	nd	609	nd
3-26	10	430,000	nd	377,000	nd	617	nd
3-27	11	441,000	nd	416,000	nd	661	nd
3-28	12	402,000	nd	363,000	nd	1,000	nd
3-30	14	426,000	nd	439,000	nd	1,160	nd
3-31	15	513,000	nd	546,000	nd	1,190	nd
4-3	18	617,000	nd	381,000	nd	1,000	nd
4-5	20	587,000	nd	549,000	nd	863	nd
4-7	22	392,000	nd	448,000	nd	692	nd
4-10	25	348,000	nd	348,000	nd	824	nd
4-12	26	372,000	nd	395,000	nd	824	nd
4-14	29	420,000	nd	nr	nd	nr	nd

KEY:

Feed = Supply reservoir for both Control and Reactive Columns

Control = Exit (top) concentration from column filled with 100% sand

Reactive = Exit (top) concentration from column filled with reactive materials in sand

nd = non-detect (25 ppb) for zinc

nr = no meaningful analytical result

Newport South Landfill laboratory Column Test
Full Metals Analysis, ppb

Run Day 9						

	Zinc Water			Barium Water		
	Feed	Control	Reactive	Feed	Control	Reactive
Na	54,345	83,379	83,349	8,218	10,526	11,300
Mg	18,393	30,026	27,821	118	<10	<10
Al	<10	19	17	<10	<10	20
K	4,875	6,363	6,480	300,088	33,456	33,863
Ca	69,008	65,235	606,986	7,058	8,726	592,178
Mn	114	<10	583	<10	<10	<10
Fe	<10	408	3,646	<10	<10	3,381
Ni	12	<4	22	<4	<4	19
Cu	<4	57	<4	<4	<4	<4
Cd	15	<4	<4	<4	<4	<4
Pb	<4	<4	<4	<4	<4	<4

Run Day 20						

	Zinc Water			Barium Water		
	Feed	Control	Reactive	Feed	Control	Reactive
Na	41,450	66,207	67,420	7,699	11,193	11,984
Mg	15,252	22,040	23,177	153	<10	<10
Al	<10	15	<10	<10	<10	32
K	4,094	5,459	5,627	34,252	40,116	40,084
Ca	52,190	51,919	599,024	7,553	8,304	581,750
Mn	62	<10	209	<10	<10	<10
Fe	375	299	3,613	<10	<10	3,436
Ni	11	<4	19	<4	<4	19
Cu	<4	<4	<4	<4	<4	<4
Cd	<4	<4	<4	<4	<4	<4
Pb	<4	<4	<4	<4	<4	<4

Wall Life Projections

Four components control wall life. Permeability maintenance, addressed above, was determined to be good. Gypsum levels must be adequate for both barium removal and to accommodate losses due to solubility in the effluent water. Iron levels must be adequate for removing zinc. The column tests were a definitive physical demonstration that all four parameters were more than adequate and would perform together as a whole.

The key to wall life projections is the amount of groundwater which will pass through the wall, requiring treatment. This groundwater flow is controlled by the nature of the landfill cap, and wall life was projected for different landfill cap configurations. The cap/infiltration performance was calculated using the HELP (Hydrologic Evaluation of Landfill Performance) Model. The table below shows rainwater infiltration rates to the landfill through the cap, the corresponding wall fluxes, the field years simulated by each day of laboratory operation, and the wall life projected after 29 days of laboratory column operation. These cases represent a wall only eight inches thick, the length of our active column. In practice, the wall will be two or three feet thick, thus giving an additional life factor of at least three times the lifetimes given below.

Cap Case	Infiltration Rate, in. H_2O/yr	Wall Flux, cm^3/cm^2/day	Field Years/ Lab Day	Wall Life, Years
Current Conditions (3 ft. soil) [base case -- no cap]	6	1.24	.054	1.5
Asphalt (4 in.) + Stone (8 in.)	0.1	.0207	3.27	90
Soil (18 in.) + Bentomat	0.02	.00413	16.4	450

Field Well-Column Test

As a final technology demonstration, we employed a significant new in-situ field test methodology that has been demonstrated by the U.S. EPA and DuPont. A 12-inch diameter column of the PRW sand:gypsum:ZVI mix was emplaced in the ground in the presence of contaminated groundwater. Central in the column was a one-inch monitoring well. Metals removal was determined by sampling the core water that had passed through six inches of reactive material. Accelerated wall life was simulated by drawing water from the central well. The results of this test further validate the laboratory projections. Detailed results of this field pilot are reported separately.

Acknowledgements

APPENDIX B

Cap and Barrier Flux Calculations Based on HELP Model Infiltration Rates
Craig Barlett
3/22/00

Assume that we cannot segragate flow from above and in waste, so just look at infiltration rates

column test
dia = 5.08 cm
length = 20.32 cm
flow = K*I*A

K = 5.70E-04 cm/sec
flow = 500 cc/day
porosity = 0.3

I = flow/(K*A) = 0.501 cm/cm   or
Flux = flow/A = 24.682 cm3/cm2/day

10.18 cm over column

lab pore changes   4.05

Flow = Area * infiltration rate

wall thickness =   0.677 ft

simulated time per day
col flux / field flux

pore chng/ day	days / pore chng	1 lab day field days	1 lab day = field yrs

wall length = 2200 ft
wall depth = 10 ft
wall thickness = 3 ft

Current condtions, HELP model
Area = 15 acres
Inf rate= 6 in/year
Flow = 4.6 gpm

residence time in wall = 22 days
vel= 4.133 cm/day
flux = 1.240 cm3/cm2/day

0.055 yrs

| 0.20028 | 4.99 | 20 | 0.06 |

Asphalt (4") + Stone (8")
Area = 15 acres
Inf rate= 0.1 in/year
Flow = 0.0775 gpm

residence time in wall = 1328 days
vel= 0.069 cm/day
flux = 0.0207 cm3/cm2/day

3.272 yrs

| 0.00334 | 299.57 | 1213 | , 3.32 |

Soil (18") + Bentomat
Area = 15 acres
Inf rate= 0.02 in/year
Flow = 0.0155 gpm

residence time in wall = 6638 days
vel= 0.014 cm/day
flux = 0.004 cm3/cm2/day

16.362 yrs

| 0.00067 | 1497.87 | 6065 | 16.62 |

1. OBJECTIVE

The objective of this analysis is to estimate the average annual infiltration for the capping systems considered for the South Landfill facility. The caps are as follows:

Case 1: 6" of topsoil

Case 2: 6" of topsoil	**Case 2-1:** 6" of topsoil
12" of barrier soil	12" of fill
	12" of barrier soil

Case 3: 6" topsoil	**Case 3-1:** 6" topsoil
bentonite mat	12" of fill
	bentonite mat

Case 3a: 6" topsoil	**Case 3a-1:** 6" topsoil
drainage net	12" of fill
bentonite mat	drainage net
	bentonite mat

Case 4: 4" asphalt	**Case 4-1:** 4" asphalt
8" stone	8" stone
synthetic liner	24" of waste
bentonite mat	

Case 4a: 4" asphalt	**Case 4a-1:** 4" asphalt
8" stone	8" stone
drainage net	drainage net
synthetic liner	24" of waste
bentonite mat	

Case 5: 6" of topsoil
12" of fill
synthetic liner
12" of barrier soil

Case 5a: 6" of topsoil
12" of fill
drainage net
synthetic liner
12" of barrier soil

Case 6: Existing cover of 5' of silty/clayey soil

Note that the only difference between cases 3, 4, 5 and 3a, 4a, 5a is the presence of the drainage net. Cases 2-1, 3-1 and 3a-1 are introduced to investigate the effect of an additional 12" layer of fill on Cases 2, 3 and 3a. Cases 4-1 and 4a-1 differ from Cases 4 and 4a in that they lack the synthetic liner and the bentonite mat. The layer of waste in Cases 4-1 and 4a-1 is introduced because a lateral drainage layer, such as stone or drainage net, can not be the lower-most layer in HELP.

2. DESIGN DATA

Climatological data

Climatological data was selected from the HELP data base for the location of Wilmington, DE. The daily precipitation, temperature and solar radiation input was generated synthetically for the period of 100 years.

Evapotranspiration data

Evapotranspiration parameters pertaining to the climatological data are obtained from the HELP data base for the location of Wilmington, DE.

In typical topsoils vegetated with grass, the evapotranspiration zone depth in relatively moist climates, such as in Delaware, is likely to be approximately 21 inches. Value of 21 inches was used in this calculation. However, the thickness of the zone available for the root growth is less than that for all cases considered in this analysis, except for Cases 2-1 and 6. For the remaining cases either the entire thickness of the cap is less than 21 inches or the thickness available for root growth is limited by the presence of the bentonite mat or a synthetic liner. Therefore, the actual depths of the evapotranspiration zone are:

Case 1:	d = 6 inches
Case 2:	d = 18 inches
Case 2-1:	d = 21 inches
Case 3:	d = 6 inches
Case 3-1:	d = 18 inches
Case 3a:	d = 6 inches
Case 3a-1:	d = 18 inches
Case 5:	d = 18 inches
Case 5a:	d = 18 inches
Case 6:	d = 21 inches

Note that the details of the cap construction are not yet specified. If fill is placed to create a uniformly graded subgrade, the evapotranspiration zone may extend deeper into the fill. Also, depending on the nature of the waste, the root growth may occur within the waste itself. For this analysis, it was assumed that there is no grading fill, and that the roots will not grow into the waste.

The cap configuration in Cases 4, 4-1, 4a and 4a-1 is different from the remaining cases because the surface is covered with asphalt. This, for all practical purposes, eliminates the evapotranspiration. Therefore, only a nominal evapotranspiration zone was assumed (d = 0.1 inches).

The maximum leaf area index was selected to be 2.0, based on the typical value for the poor to fair stand of grass.

LAI = 2.0

For the asphalt cap, the maximum LAI is zero (no vegetation).

Runoff parameters

It was assumed that the typical slopes of the landfill surface will be 4 percent, and that surface water collection swales will be located every 200 feet. The surface type for the calculation of the CN curve number was based on a poor stand of grass.

S = 4 %
L = 200 feet
Poor grass

For the asphalt cap, the CN number was user-specified at the value of 95. This was assumed based on the TR55 guidance for asphalt parking lots.

Soil data

Soil and material types were selected from the HELP data base. Properties are listed in Table 4 of the HELP manual. Short descriptions are provided below:

Existing soil:	HELP soil type #12, silty clay
Topsoil:	HELP soil type #6, sandy loam
Fill:	HELP soil type #4, loamy sand
Barrier soil:	HELP soil type #16, barrier soil (clay), hydraulic conductivity = $1*10^{-7}$ cm/s
Stone:	HELP soil type #21, gravel
Bentonite mat:	HELP material type #17
Synthetic liner:	HELP material type #36, LDPE, 40 mil, good quality installation
Drainage net:	HELP material type #20

Asphalt was modeled by assuming that its properties are similar to those of a barrier soil layer (HELP soil #16). This is probably a good assumption regarding hydraulic conductivity (on the order of 10^{-7} cm/sec). Remaining soil properties, such as wilting point and field capacity, are probably not relevant to asphalt.

The waste was modeled as a clayey soil with the hydraulic conductivity of $1.7*10^{-5}$ cm/s (HELP soil #15).

```
****************************************************************************
****************************************************************************
**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**                HELP MODEL VERSION 3.05   (30 MARCH 1996)               **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                  USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY           **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************
```

PRECIPITATION DATA FILE: C:\HELP3\predup1.D4
TEMPERATURE DATA FILE: C:\HELP3\temdup1.D7
SOLAR RADIATION DATA FILE: C:\HELP3\sordup1.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\evadup1.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\capdup3a.D10
OUTPUT DATA FILE: C:\HELP3\~~outdup3a~~.OUT
                                    Odup3a-1

TIME: 14:32   DATE: 3/20/2000

```
*****************************************************************************

      TITLE:  DuPont S. Landfill Case 3a-1 - 6" topsoil, 12" fill, drainage net,
                              bentonite mat, vegetated

*****************************************************************************
```

     NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                            LAYER   1

                TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   6
         THICKNESS   =   6.00   INCHES
         POROSITY   =   0.4530 VOL/VOL
         FIELD CAPACITY   =   0.1900 VOL/VOL
         WILTING POINT   =   0.0850 VOL/VOL
         INITIAL SOIL WATER CONTENT =   0.1877 VOL/VOL
         EFFECTIVE SAT. HYD. COND. = 0.720000011000E-03 CM/SEC
      NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00
             FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 4

```
THICKNESS                      =        12.00   INCHES
POROSITY                       =         0.4370 VOL/VOL
FIELD CAPACITY                 =         0.1050 VOL/VOL
WILTING POINT                  =         0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT     =         0.1841 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.170000002000E-02 CM/SEC
```


LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

```
THICKNESS                      =         0.20   INCHES
POROSITY                       =         0.8500 VOL/VOL
FIELD CAPACITY                 =         0.0100 VOL/VOL
WILTING POINT                  =         0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT     =         0.1107 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  10.0000000000      CM/SEC
SLOPE                          =         4.00   PERCENT
DRAINAGE LENGTH                =       200.0    FEET
```


LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

```
THICKNESS                      =         0.30   INCHES
POROSITY                       =         0.7500 VOL/VOL
FIELD CAPACITY                 =         0.7470 VOL/VOL
WILTING POINT                  =         0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT     =         0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.300000003000E-08 CM/SEC
```


GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
       SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
       POOR STAND OF GRASS, A SURFACE SLOPE OF 4.%
       AND A SLOPE LENGTH OF 200. FEET.

```
SCS RUNOFF CURVE NUMBER             =        80.60
FRACTION OF AREA ALLOWING RUNOFF    =       100.0    PERCENT
```

```
AREA PROJECTED ON HORIZONTAL PLANE   =    1.000   ACRES
EVAPORATIVE ZONE DEPTH               =   18.2     INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =    3.357   INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =    8.132   INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =    1.075   INCHES
INITIAL SNOW WATER                   =    0.000   INCHES
INITIAL WATER IN LAYER MATERIALS     =    3.582   INCHES
TOTAL INITIAL WATER                  =    3.582   INCHES
TOTAL SUBSURFACE INFLOW              =    0.00    INCHES/YEAR
```


EVAPOTRANSPIRATION AND WEATHER DATA

```
NOTE:   EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
        WILMINGTON            DELAWARE

        STATION LATITUDE                        =  39.80 DEGREES
        MAXIMUM LEAF AREA INDEX                 =   2.00
        START OF GROWING SEASON (JULIAN DATE)   =    107
        END OF GROWING SEASON (JULIAN DATE)     =    298
        EVAPORATIVE ZONE DEPTH                  =  18.2   INCHES
        AVERAGE ANNUAL WIND SPEED               =   9.20  MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  67.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  67.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  72.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  71.00 %


NOTE:   PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
        COEFFICIENTS FOR    WILMINGTON            DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

```
NOTE:   TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
        COEFFICIENTS FOR    WILMINGTON            DELAWARE
```

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

```
NOTE:   SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
        COEFFICIENTS FOR    WILMINGTON            DELAWARE
        AND STATION LATITUDE  =  39.80 DEGREES
```

```
*****************************************************************************
          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH  100
-----------------------------------------------------------------------------

                     JAN/JUL   FEB/AUG   MAR/SEP   APR/OCT   MAY/NOV   JUN/DEC
                     -------   -------   -------   -------   -------   -------
PRECIPITATION
-------------
    TOTALS            3.28      2.98      4.08      3.39      3.39      3.46
                      3.88      3.97      3.47      2.85      3.12      3.35

    STD. DEVIATIONS   1.67      1.45      1.88      1.46      1.63      1.83
                      1.87      2.39      2.16      1.84      1.64      1.72

RUNOFF
------
    TOTALS           0.663     1.173     0.609     0.018     0.021     0.049
                     0.078     0.107     0.130     0.070     0.046     0.167

    STD. DEVIATIONS  0.923     1.214     1.010     0.050     0.056     0.121
                     0.215     0.226     0.245     0.192     0.112     0.433

EVAPOTRANSPIRATION
------------------
    TOTALS           0.819     0.785     2.316     3.138     3.331     3.732
                     3.378     3.161     2.589     2.068     1.245     0.931

    STD. DEVIATIONS  0.278     0.418     0.424     0.763     1.139     1.301
                     1.287     1.204     0.967     0.797     0.232     0.177

LATERAL DRAINAGE COLLECTED FROM LAYER  3
----------------------------------------
    TOTALS           1.2455    0.9202    2.3992    0.7372    0.3231    0.2815
                     0.1429    0.4367    0.7339    0.6082    1.0277    1.6761

    STD. DEVIATIONS  1.3671    1.1513    1.6261    0.8390    0.5210    0.5400
                     0.3116    0.9148    1.0661    0.9960    1.2879    1.4233

PERCOLATION/LEAKAGE THROUGH LAYER  4
------------------------------------
    TOTALS           0.0024    0.0015    0.0036    0.0027    0.0018    0.0007
                     0.0003    0.0008    0.0014    0.0012    0.0021    0.0033

    STD. DEVIATIONS  0.0016    0.0015    0.0011    0.0010    0.0012    0.0009
                     0.0005    0.0012    0.0015    0.0014    0.0016    0.0014


----------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
----------------------------------------------------------------------------


DAILY AVERAGE HEAD ON TOP OF LAYER  4
-------------------------------------
```

```
AVERAGES          0.0533   0.0440   0.1037   0.0328   0.0139   0.0126
                  0.0062   0.0188   0.0327   0.0262   0.0458   0.0723

STD. DEVIATIONS   0.0585   0.0551   0.0703   0.0374   0.0225   0.0241
                  0.0134   0.0394   0.0475   0.0429   0.0574   0.0614
```

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.20	(6.096)	149568.3	100.00
RUNOFF	3.133	(2.1088)	11371.43	7.603
EVAPOTRANSPIRATION	27.494	(3.4881)	99803.07	66.727
LATERAL DRAINAGE COLLECTED FROM LAYER 3	10.53222	(3.61431)	38231.949	25.56152
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.02197	(0.00518)	79.747	0.05332
AVERAGE HEAD ON TOP OF LAYER 4	0.039	(0.013)		
CHANGE IN WATER STORAGE	0.000	(1.0649)	0.02	0.000

****
```
```

```
****************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------
                                        (INCHES)      (CU. FT.)
                                        ----------    --------------
        PRECIPITATION                     5.26         19093.801

        RUNOFF                            3.034        11012.0889

        DRAINAGE COLLECTED FROM LAYER  3  1.63809       5946.27100

        PERCOLATION/LEAKAGE THROUGH LAYER  4   0.000858      3.11324

        AVERAGE HEAD ON TOP OF LAYER   4   2.263

        MAXIMUM HEAD ON TOP OF LAYER   4   3.926

        LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)         20.4 FEET

        SNOW WATER                        6.60         23975.8555


        MAXIMUM VEG. SOIL WATER (VOL/VOL)          0.3173

        MINIMUM VEG. SOIL WATER (VOL/VOL)          0.0591


        ***   Maximum heads are computed using McEnroe's equations.   ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.



****************************************************************************
```

```
************************************************************************

              FINAL WATER STORAGE AT END OF YEAR   100
------------------------------------------------------------------------
          LAYER         (INCHES)        (VOL/VOL)
          -----         --------        ---------
            1            1.1240          0.1873

            2            2.2118          0.1843

            3            0.0223          0.1113

            4            0.2250          0.7500

     SNOW WATER          0.000


************************************************************************
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```

```
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********************************************************************
**                                                              **
**                                                              **
**            HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE      **
**             HELP MODEL VERSION 3.05  (30 MARCH 1996)          **
**             DEVELOPED BY ENVIRONMENTAL LABORATORY             **
**               USAE WATERWAYS EXPERIMENT STATION               **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY     **
**                                                              **
**                                                              **
********************************************************************
********************************************************************
```

PRECIPITATION DATA FILE: C:\HELP3\predup1.D4
TEMPERATURE DATA FILE: C:\HELP3\temdup1.D7
SOLAR RADIATION DATA FILE: C:\HELP3\sordup1.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\evadup1.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\capdup6.D10
OUTPUT DATA FILE: C:\HELP3\outdup6.OUT

TIME: 11:52   DATE: 2/21/2000


```
********************************************************************

     TITLE:  DuPont S. Landfill Case 6 - Existing conditions (5 ft of soil)

********************************************************************
```


NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
        COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                         LAYER   1

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   12
         THICKNESS   =   60.00   INCHES
         POROSITY   =   0.4710 VOL/VOL
         FIELD CAPACITY   =   0.3420 VOL/VOL
         WILTING POINT   =   0.2100 VOL/VOL
         INITIAL SOIL WATER CONTENT   =   0.3928 VOL/VOL
         EFFECTIVE SAT. HYD. COND.   = 0.419999997000E-04 CM/SEC
       NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

                                            AR324426

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
       SOIL DATA BASE USING SOIL TEXTURE #12 WITH A
       POOR STAND OF GRASS, A SURFACE SLOPE OF 4.%
       AND A SLOPE LENGTH OF 200. FEET.

```
SCS RUNOFF CURVE NUMBER                 =      91.80
FRACTION OF AREA ALLOWING RUNOFF        =     100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE      =       1.000  ACRES
EVAPORATIVE ZONE DEPTH                  =      21.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE       =       7.588  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE      =       9.891  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE      =       4.410  INCHES
INITIAL SNOW WATER                      =       0.000  INCHES
INITIAL WATER IN LAYER MATERIALS        =      23.566  INCHES
TOTAL INITIAL WATER                     =      23.566  INCHES
TOTAL SUBSURFACE INFLOW                 =       0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
       WILMINGTON   DELAWARE

```
STATION LATITUDE                        =   39.80 DEGREES
MAXIMUM LEAF AREA INDEX                  =    2.00
START OF GROWING SEASON (JULIAN DATE)    =     107
END OF GROWING SEASON (JULIAN DATE)      =     298
EVAPORATIVE ZONE DEPTH                   =   21.0  INCHES
AVERAGE ANNUAL WIND SPEED                =    9.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =   67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =   67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =   72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =   71.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
       COEFFICIENTS FOR   WILMINGTON   DELAWARE

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.11	2.99	3.87	3.39	3.23	3.51
3.90	4.03	3.59	2.89	3.33	3.54

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
       COEFFICIENTS FOR   WILMINGTON   DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.20	33.20	41.80	52.40	62.20	71.20
76.00	74.80	67.80	56.30	45.60	35.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
       COEFFICIENTS FOR   WILMINGTON   DELAWARE
       AND STATION LATITUDE = 39.80 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.28	2.98	4.08	3.39	3.39	3.46
	3.88	3.97	3.47	2.85	3.12	3.35
STD. DEVIATIONS	1.67	1.45	1.88	1.46	1.63	1.83
	1.87	2.39	2.16	1.84	1.64	1.72
RUNOFF						
TOTALS	0.966	1.445	1.175	0.290	0.301	0.436
	0.536	0.651	0.696	0.454	0.398	0.580
STD. DEVIATIONS	0.993	1.314	1.206	0.346	0.368	0.513
	0.595	0.833	0.797	0.640	0.524	0.704
EVAPOTRANSPIRATION						
TOTALS	0.788	0.769	2.271	3.296	3.382	4.033
	3.156	2.874	2.524	2.137	1.119	0.844
STD. DEVIATIONS	0.258	0.402	0.432	0.678	1.159	1.201
	1.176	1.220	0.962	0.775	0.250	0.181
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	1.0200	0.8288	1.2119	1.2588	0.5936	0.1776
	0.0423	0.0120	0.0510	0.1316	0.1603	0.5828
STD. DEVIATIONS	0.8319	0.6953	0.8669	0.6683	0.3455	0.2471
	0.1459	0.0588	0.2484	0.2907	0.3251	0.9457

****

```
***********************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH  100
  --------------------------------------------------------------------
                               INCHES              CU. FEET        PERCENT
                           -----------------    --------------    ---------
  PRECIPITATION             41.20   (   6.096)      149568.3       100.00

  RUNOFF                     7.928  (  2.8538)      28778.75        19.241

  EVAPOTRANSPIRATION        27.193  (  3.4179)      98709.46        65.996

  PERCOLATION/LEAKAGE THROUGH 6.07057 (  2.24509)    22036.182      14.73319
       LAYER   1

  CHANGE IN WATER STORAGE   -0.011  (  1.8144)        -38.19        -0.026

***********************************************************************
```

```
***********************************************************************

               PEAK DAILY VALUES FOR YEARS     1 THROUGH   100
----------------------------------------------------------------------
                                           (INCHES)      (CU. FT.)
                                           ----------    -------------
         PRECIPITATION                       5.26         19093.801

         RUNOFF                              3.387        12293.9980

         PERCOLATION/LEAKAGE THROUGH LAYER  1   0.726442    2636.98267

         SNOW WATER                          6.60         23975.8555


         MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.4357

         MINIMUM VEG. SOIL WATER (VOL/VOL)              0.2100

***********************************************************************
```

```
***********************************************************************

              FINAL WATER STORAGE AT END OF YEAR   100
    -----------------------------------------------------------------
              LAYER        (INCHES)        (VOL/VOL)
              -----        --------        ---------
                1          22.5144          0.3752

          SNOW WATER        0.000

***********************************************************************
***********************************************************************
```

```
*********************************************************************
*********************************************************************
**                                                               **
**                                                               **
**           HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**             HELP MODEL VERSION 3.05   (30 MARCH 1996)          **
**             DEVELOPED BY ENVIRONMENTAL LABORATORY              **
**               USAE WATERWAYS EXPERIMENT STATION               **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                               **
**                                                               **
*********************************************************************
*********************************************************************
```

PRECIPITATION DATA FILE: C:\HELP3\predup1.D4
TEMPERATURE DATA FILE: C:\HELP3\temdup1.D7
SOLAR RADIATION DATA FILE: C:\HELP3\sordup1.D13
EVAPOTRANSPIRATION DATA: C:\HELP3\evadup3.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\capdup4.D10
OUTPUT DATA FILE: C:\HELP3\outdup4.OUT
                                      ovdup4-1

TIME: 14:38   DATE: 3/20/2000

```
*********************************************************************

     TITLE:  DuPont S. Landfill Case 4-1 - 4" asphalt, 8" stone, 24" waste

*********************************************************************
```

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
        COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                          LAYER   1

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER 16
        THICKNESS   =   4.00   INCHES
        POROSITY   =   0.4270 VOL/VOL
        FIELD CAPACITY   =   0.4180 VOL/VOL
        WILTING POINT   =   0.3670 VOL/VOL
        INITIAL SOIL WATER CONTENT   =   0.4169 VOL/VOL
        EFFECTIVE SAT. HYD. COND.   = 0.100000001000E-06 CM/SEC

                          LAYER   2

```
                            --------


                  TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   21
      THICKNESS                      =        8.00   INCHES
      POROSITY                       =        0.3970 VOL/VOL
      FIELD CAPACITY                 =        0.0320 VOL/VOL
      WILTING POINT                  =        0.0130 VOL/VOL
      INITIAL SOIL WATER CONTENT     =        0.0321 VOL/VOL
      EFFECTIVE SAT. HYD. COND.      =  0.300000012000       CM/SEC
      SLOPE                          =        4.00   PERCENT
      DRAINAGE LENGTH                =      200.0    FEET




                            LAYER   3

                            --------


                  TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   15
      THICKNESS                      =       24.00   INCHES
      POROSITY                       =        0.4750 VOL/VOL
      FIELD CAPACITY                 =        0.3780 VOL/VOL
      WILTING POINT                  =        0.2650 VOL/VOL
      INITIAL SOIL WATER CONTENT     =        0.4750 VOL/VOL
      EFFECTIVE SAT. HYD. COND.      =  0.170000003000E-04 CM/SEC




             GENERAL DESIGN AND EVAPORATIVE ZONE DATA
             ----------------------------------------


      NOTE:   SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

   SCS RUNOFF CURVE NUMBER              =       95.00
   FRACTION OF AREA ALLOWING RUNOFF    =      100.0     PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE  =        1.000   ACRES
   EVAPORATIVE ZONE DEPTH              =        0.1     INCHES
   INITIAL WATER IN EVAPORATIVE ZONE   =        0.037   INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE  =        0.043   INCHES
   LOWER LIMIT OF EVAPORATIVE STORAGE  =        0.037   INCHES
   INITIAL SNOW WATER                  =        0.000   INCHES
   INITIAL WATER IN LAYER MATERIALS    =       13.324   INCHES
   TOTAL INITIAL WATER                 =       13.324   INCHES
   TOTAL SUBSURFACE INFLOW             =        0.00    INCHES/YEAR




              EVAPOTRANSPIRATION AND WEATHER DATA
              -----------------------------------


      NOTE:   EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              WILMINGTON             DELAWARE

         STATION LATITUDE                        =   39.80 DEGREES
         MAXIMUM LEAF AREA INDEX                 =    0.00
```

```
        START OF GROWING SEASON (JULIAN DATE)   =    107
        END OF GROWING SEASON (JULIAN DATE)     =    298
        EVAPORATIVE ZONE DEPTH                  =    0.1   INCHES
        AVERAGE ANNUAL WIND SPEED               =    9.20 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =   67.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =   67.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =   72.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =   71.00 %


    NOTE:   PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR      WILMINGTON            DELAWARE

         NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
    -------      -------      -------      -------      -------      -------
      3.11         2.99         3.87         3.39         3.23         3.51
      3.90         4.03         3.59         2.89         3.33         3.54


    NOTE:   TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR      WILMINGTON            DELAWARE

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
    -------      -------      -------      -------      -------      -------
     31.20        33.20        41.80        52.40        62.20        71.20
     76.00        74.80        67.80        56.30        45.60        35.50


    NOTE:   SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR      WILMINGTON            DELAWARE
            AND STATION LATITUDE  =  39.80 DEGREES
```

****

```
    AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH  100
------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
PRECIPITATION
-------------
   TOTALS            3.28     2.98     4.08     3.39     3.39     3.46
                     3.88     3.97     3.47     2.85     3.12     3.35

   STD. DEVIATIONS   1.67     1.45     1.88     1.46     1.63     1.83
                     1.87     2.39     2.16     1.84     1.64     1.72
RUNOFF
```

```
------
     TOTALS                2.538    2.629    3.693    2.682    2.732    2.960
                           3.353    3.400    3.106    2.549    2.690    2.725

     STD. DEVIATIONS       1.658    1.478    1.848    1.172    1.350    1.587
                           1.649    2.122    1.950    1.693    1.514    1.530

EVAPOTRANSPIRATION
------------------
     TOTALS                0.518    0.434    0.683    0.707    0.649    0.498
                           0.521    0.563    0.364    0.296    0.393    0.396

     STD. DEVIATIONS       0.164    0.157    0.276    0.383    0.374    0.347
                           0.368    0.347    0.272    0.217    0.174    0.144

LATERAL DRAINAGE COLLECTED FROM LAYER  2
----------------------------------------
     TOTALS                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

     STD. DEVIATIONS       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

PERCOLATION/LEAKAGE THROUGH LAYER  3
------------------------------------
     TOTALS                0.0229   0.0139   0.0124   0.0094   0.0054   0.0035
                           0.0032   0.0042   0.0037   0.0035   0.0067   0.0123

     STD. DEVIATIONS       0.0116   0.0122   0.0094   0.0070   0.0038   0.0033
                           0.0026   0.0035   0.0034   0.0032   0.0046   0.0083


-------------------------------------------------------------------------------
          AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


DAILY AVERAGE HEAD ON TOP OF LAYER  3
-------------------------------------
     AVERAGES              0.0003   0.0002   0.0001   0.0001   0.0001   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0001   0.0001

     STD. DEVIATIONS       0.0001   0.0001   0.0001   0.0001   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0001   0.0001

*******************************************************************************


*******************************************************************************
```

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.20	(6.096)	149568.3	100.00
RUNOFF	35.059	(5.4547)	127263.97	85.088
EVAPOTRANSPIRATION	6.021	(1.0588)	21856.10	14.613

LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.00004 (0.00002)	0.139	0.00009
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.10114 (0.03110)	367.131	0.24546
AVERAGE HEAD ON TOP OF LAYER 3	0.000 (0.000)		
CHANGE IN WATER STORAGE	0.000 (0.6678)	-1.12	-0.001

****

```
*****************************************************************************

              PEAK DAILY VALUES FOR YEARS     1 THROUGH   100
-----------------------------------------------------------------------------
                                             (INCHES)      (CU. FT.)
                                             ----------    -------------
    PRECIPITATION                             5.26          19093.801

    RUNOFF                                    5.214         18925.9961

    DRAINAGE COLLECTED FROM LAYER  2          0.00000            0.01687

    PERCOLATION/LEAKAGE THROUGH LAYER  3      0:004117          14.94479

    AVERAGE HEAD ON TOP OF LAYER  3           0.001

    MAXIMUM HEAD ON TOP OF LAYER  3           0.011

    LOCATION OF MAXIMUM HEAD IN LAYER  2
          (DISTANCE FROM DRAIN)               0.0 FEET

    SNOW WATER                                6.60          23975.8555


    MAXIMUM VEG. SOIL WATER (VOL/VOL)                0.4270

    MINIMUM VEG. SOIL WATER (VOL/VOL)                0.3670


      ***   Maximum heads are computed using McEnroe's equations.   ***

         Reference:  Maximum Saturated Depth over Landfill Liner
                     by Bruce M. McEnroe, University of Kansas
                     ASCE Journal of Environmental Engineering
                     Vol. 119, No. 2, March 1993, pp. 262-270.


*****************************************************************************
```

```
*************************************************************************
            FINAL WATER STORAGE AT END OF YEAR   100
        -------------------------------------------------------------
            LAYER          (INCHES)         (VOL/VOL)
            -----          --------         ---------
              1            1.6371            0.4093

              2            0.2560            0.0320

              3           11.4000            0.4750

        SNOW  WATER        0.000

*************************************************************************
*************************************************************************
```

APPENDIX C

Appendix C - Field Investigations
Table of Contents

APPENDIX C.1

GEOPROBE® INVESTIGATION

FIELD TEST LOCATIONS

SOUTH LANDFILL
NEWPORT SUPERFUND SITE
NEWPORT, DELAWARE

Corporate Remediation Group

An Alliance Between
DuPont and The E C Diamond Group

Barley Mill Plaza, Building 27/
Wilmington, Delaware 19880 0027

SCALE

125   0   125 FEET

AR324442

LEGEND

WB-2   WASTE BORING LOCATIONS-12/94

CS-1   GEOPROBE LOCATIONS- 7/00

EA-14   TEST HOLE LOCATION-5/93

MW-15A   MONITORING WELL

NEW CASTLE COUNTY SEWER MAIN

PROPOSED ALIGNMENT

LIMITS OF WASTE (DASHED WHERE APPROXIMATE)

SECTION A-A'

EAST
A

GS-22C
GS-21
GS-20B
GS-20A
GS-19
GS-17
GS-16
GS-15
GS-14
GS-13
GS-12
GS-11
GS-10

GROUND SURFACE

WEST
A'

25 X VERTICAL EXAGGERATION

VERTICAL SCALE
HORIZONTAL SCALE

SITE PLAN

A
A'

LEGEND

= FILL

= (ML) SILT

= (MH) SILT OF HIGH PLASTICITY,
  ELASTIC SILT

= (OL, OH) ORGANIC SILT, ORGANIC CLAY
  MARSH DEPOSIT

= BARITE ORE WASTE

= (ML+) SILTY, SILTY SAND
  AND BARITE ORE WASTE

= (GM) SILTY GRAVEL

= (SW, SM) WELL-GRADED SAND, FINE
  TO COARSE SAND, SILTY SAND

CROSS SECTION A-A'

DuPont Newport Facility
South Landfill
Newport, Delaware

AR324443

SOUTH
B

NORTH
B'

GROUND SURFACE

GS-10 GS-9 GS-8 GS-7 GS-6 GS-5 GS-4 GS-3 GS-2

SECTION B-B'

SITE PLAN

25 X VERTICAL EXAGGERATION

HORIZONTAL SCALE

VERTICAL SCALE

AR324444

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
				20"		6" top soil - dark brown w/organics 6" sand & soil - brown to dark brown 6" gravel & sand - light brown 4" black sandy material		
	4			24"		4" black sandy material 14" wood 6" wet, medium tan		
	8			24"		12" tan sandy silt 12" medium gray silty sand		
	12							
	16							
	20							
	24							
	28							
	32							

PROJECT NO.: 44DINE7105.2K
DATE BEGAN: 2/23/00   9:55
DATE COMPLETED: 2/23/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe with 4ft. sleeves

NOTES:
All descriptions are visual only – cores were not removed from plastic sleeves

F-188

BORING NO

AR324445

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 622707.2 E 602210.5
SURFACE EL: _____

DESCRIPTION:

Dark brown - orange brown, clayey SILT w/ tr. c-f. sand & organics

Lt. gray, silty F-C SAND w/ some f. gravel, 7"
12"

Orange brown - Dark orange brown F-C SAND w/ some silt & f. gravel layers

14"-18" - Lt. gray rock fragment layer
22"-24" - Dark brown rock fragment layer

30"

orange brown w/ gray, silty c-f SAND w/ some c-f gravel & clay

48"

orange brown, clayey c-F SAND w/ some silt & f. gravel

72"

Dark greenish gray, clayey SILT w/ some c-f sand, & tr. organics

84"

Sample Recovery: 42" (at ~2'), 40" (at ~6')

PROJECT NO.: Newport SLF
DATE BEGAN: 2/23/00
DATE COMPLETED: 2/23/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH ___ DATE/TIME _____
GWL: DEPTH ___ DATE/TIME _____
DRILLING METHOD: Geoprobe w/4 ft sleeves

AR324446

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N _____ E _____		
						SURFACE EL: _____		
	8					Greenish Gray, silty C-F SAND & tr. clay & organics — — — 90" Greenish gray, silty CLAY & tr. c-f Sand, organic - ASPHALT RUBBLE (<1" thick) 96" END of SAMPLE		

AR324447

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

Field Log

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N 622614 E 602236		
						SURFACE EL: _____		
						DESCRIPTION		
						Dark brown, SILT w some clay & tr. f. gravel, high organic content (MH)		
	1					— — — — — 6"		
						greenish gray, f. gravelly c-f SAND w tr. silt (SM/SW)		
	2			36"		— — — — — 24"		
						Dark orange brown SAA		
	3							
	4					— — — — — 48"		
						Dark orange brown, silty c-f SAND w some f. gravel & tr. clay (SM)		
	5							
	6			36"		— — — — — 72"		
						Dark greenish gray, silty c-f SAND/ c-f sandy SILT w tr. f. gravel & clay (SM/ML)		
	7					84"		

AR324448

PROJECT NO.: Newport SLF
DATE BEGAN: 2/23/00
DATE COMPLETED: 2/23/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy Env.

F-188

BORING NO.

LOG OF BORING NO. GS-3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES

N _____ E _____

SURFACE EL: _____

DESCRIPTION

Dark greenish gray / Dark orange brown silty m-F SAND / m-F sandy SILT w̲ some clay, organic (SM/ML)   96"

Dark orange brown, silty c-F SAND w̲ tr. f. gravel 3 clay, very wet w̲ mica (SM)   108"

Dark greenish gray ~~~~~ c-F sandy SILT, tr. F. gravel & organics & clay (ML)   120"

Dark greenish gray, m-F sandy SILT w̲ tr. F. gravel, c sand, & clay, organic (OL)   132"

Orange brown w̲ dark greenish gray areas, silty F. SAND w̲ some m. sand & tr. f. gravel, c sand & clay (SM)

- <½" layer of asphalt on bottom   144"

END OF SAMPLE @ 12'

9.5' WRK

from field notes

Sample recovery: 24"

Depth markings: 8, 9, 10, 11, 12

REMARKS: refusal at 9.5 ft

AR324449

PROJECT NO.: _____	GWL: DEPTH ____ DATE/TIME ____	NOTES:
DATE BEGAN: _____	GWL: DEPTH ____ DATE/TIME ____	
DATE COMPLETED: _____	DRILLING METHOD: _____	
FIELD GEOLOGIST: _____		
CHECKED BY: _____		

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-4

AR324450

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 622507.1   E 6022304.4
SURFACE EL: _____

DESCRIPTION

Dark Brown, Clayey SILT w̄ some c-f sand, high organic content   (MH) — 6" | MH

Dark gray, clayey organic SILT, w̄ some c-f sand   (OL) — 12" | OL

Orange brown - dark orange brown silty m-f. SAND w̄ some c.sand & tr. f. gravel & clay   (SM) — 24" | SM

Light orange brown, ⟨⟩ SILT w some m-f. sand, tr. c.sand & clay   (ML) — 36" | ML

Orange brown, m-f sandy SILT / silty m-f. SAND w̄ tr. c.sand & f. fine gravel & clay   (ML/SM) — 48" | ML/SM

Fractured Rock layer (Quartz) — 50"

Orange brown, silty m-f SAND / m-f sandy SILT w̄ some c.sand, tr. f. gravel & rock fragments   (SM/ML) — 84" | SM/ML

Sample recovery: 44", 42"

Depth: 1, 2, 3, 4, 5, 6, 7

PROJECT NO.: Newport SLF
DATE BEGAN: 2/23/00
DATE COMPLETED: 2/23/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy Env.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-4

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES

N _____ E _____

SURFACE EL: _____

Dark gray, ~~sandy~~ SILT, highly organic w tr. clay & f. gravel

(OL) 96"

_ SAA _ _ _ _ _ 100"

orange brown - dark orange brown silty m. - f SAND w tr. clay, c. sand & f. gravel   (SM)

44"

126"

Orange brown - light red brown, silty m.-f. SAND/m-f sandy CLAY w some silt   (SC/SM)

144"

END of Sample @ 12'

AR324451

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

NOTES:

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-5

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N 622413.7 E 602261.5 SURFACE EL: _____	USCS SYMBOL	REMARKS
						DESCRIPTION		

Dark brown, m-f sandy SILT, ≈ tr. clay, c. sand, & f. gravel (ML) ≈ tr. organics   — 3

Orange brown - dark orange brown, silty F. SAND / f. sandy SILT ≈ some m. sand & tr. f. gravel, c. sand, & clay (SM/ML)

46"

(depth markers 1, 2, 3, 4, 5, 6, 7)

— — — — — 48"

SAA

— 2" layer of quartz rock fragments
— — — — — 60"

Orange brown, silty F. sand ≈ some medium sand, tr. f. gravel, c. sand & clay (SM)

44"

84"

AR324452

PROJECT NO.: _Newport SLF_	GWL: DEPTH _____ DATE/TIME _____
DATE BEGAN: _2/23/00_	GWL: DEPTH _____ DATE/TIME _____
DATE COMPLETED: _2/23/00_	DRILLING METHOD: _____
FIELD GEOLOGIST: _R. Kahl_	_Geoprobe w/ 4 ft. sleeves_
CHECKED BY: _T. Campbell_	

NOTES:
driller: Hardy Env.

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. 6S-5

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

DESCRIPTION

orange-brown, silty m-f. SAND
tr. c. sand & f. gravel (sm)

— 98"

SAA, tr. clay (sm)

— 120"

Dark orange-brown, c-f. SAND,
w some f. gravel & silt
(sw/sm)

— 138"

Dark Gray/Black   SAA
(sw/sm)   — 144"

END of SAMPLE @ 12'

Depth marks: 8, 9, 10, 11, 12

Sample Recovery: 30"

AR324453

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-6

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N 622336.3 E 602298.8 SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	1 2 3 4			44"		Dark Brow-Gray, Sandy SILT w some clay & C-F gravel, high organic content (ML/SM) _ _ _ 6" Orange-brown w some light gray layers, silty C-f SAND w some f.gravel & rock fragments, tr. clay (SM) _ _ _ _ _ _ 48"		
	5 6			46"		Orange brown, light. gray, silty m-f SAND / m-f sandy SILT w some c sand, tr. f. gravel & clay (SM/ML)		

PROJECT NO.: Newport SLF
DATE BEGAN: 2/23/00
DATE COMPLETED: 2/23/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: J. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Environmental

F-188

BORING NO.

AR324454

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-6

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	8			44"		SAA 96" Light gray - blueishgrey, clayey SILT w some c-f. sand, tr. f. gravel (ML) 120" Light orange brown - dark orange brown, c-f. SAND w some s. lt, tr. f. gravel, & clay (SM) END of Sample @ 12'		
	9							
	10							
	11							
	12							

PROJECT NO.: _____	GWL: DEPTH _____ DATE/TIME _____
DATE BEGAN: _____	GWL: DEPTH _____ DATE/TIME _____
DATE COMPLETED: _____	DRILLING METHOD: _____
FIELD GEOLOGIST: _____	_____
CHECKED BY: _____	

NOTES:

F-188

BORING NO.

AR324455

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-7

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N 622237.8 E 602347.1 SURFACE EL: _____		

DESCRIPTION

Gray, blueish gray, c-f sandy SILT w/ some f.gravel (ML)

Orange brown, silty m-f SAND w/ ~~some~~ tr.f.gravel & c.sand (SM) 6"

Blueish gray, c-f sandy SILT w/ some f.gravel (ML) 18"

24"

Orange brown - dark orange brown, m-f sandy SILT / silty m-f SAND w/ tr. c.sand, f.gravel. & (ML/SM)

48"

SAA, tr. clay (ML/SM)

54"

Orange brown, silty m-f SAND w/ tr. c.sand & f.gravel (SM)

72"

Lt. gray - orange brown, silty m-f SAND / m-f sandy SILT w/ some f.gravel & tr.clay & c.sand (ML/SM)

Sample recovery: 40" (depth ~2), 41" (depth ~6)

PROJECT NO.: Newport SLF
DATE BEGAN: 2/24/00
DATE COMPLETED: 2/24/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4ft sleeves

AR324456

NOTES:
driller: Hardy Env.

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-7

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	8					SAA		
						96"		
						Orange brown, silty m-f SAND/ m-f sandy SILT ⪰ som f. gravel tr c. sand & clay, wet (ML/SM)		
	9					114"		
	10			36"		Brown-orange brown, m-f sandy SILT ≈ tr. f gravel, c. sand & clay (ML)		
	11					132" END of SAMPLE @ 11'		
	12							

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-8

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 622103.7 E 602288.9
SURFACE EL: _____

Dark brown, SILT w some clay & tr. c-f sand, high organic content (MH)
_ _ _ _ 10"

Dark orange brown - orange brown silty m-f SAND w tr. f. gravel & c. sand (SM)

40" (sample recovery)

_ _ _ _ 40"
Dark orange brown, E. gravelly c-f sand w some tr. silt (SW/SM) _ _ 48"

Orange brown, silty m-f SAND w tr. f. gravel & c. sand (SM

72"

20" (sample recovery)

Dark greenish gray, Dark brownish gray silty CLAY/clayey SILT w tr. f. gravel & c-f sand. Very highly organic (OH/OL)

AR324458

PROJECT NO.: Newport SLF
DATE BEGAN: 2/24/00
DATE COMPLETED: 2/24/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy Env.

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-8   2/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

SAA

— — — — — 96"

Dark orangebrown, F. gravelly C-F SAND w tr.silt. (SW)

6"

— — — — 144"

SAA   150"

Dark orangebrown, silty c-f SAND w some F. gravel tr. clay (SM)

44"

Depths: 8, 9, 10, 11, 12, 13, 14

AR3244591

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

F-188   BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-8

3/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
	–15– –16–					SAA ‾ ‾ ‾ ‾ ‾ ‾174' Grayish Brown, F. sandy SILT w̅ some clay & tr. f.gravel & m.-f. sand (ML) 192" END OF SAMPLE @ 16'		

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

F-188

BORING NO.

The W-C Diamond Group

A Division of URS Corporation

LOG OF BORING NO. GS-9

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N 621974.9 **E** 602332.2		
						SURFACE EL: _____		
						DESCRIPTION		
						Dark Brown clayey SILT w tr. c-f sand & f. gravel, high organic content		
						(MH) 8"		
	1					Orange brown, silty m-f SAND w tr. f. gravel, c. sand, & clay		
						(SM)		
	2			40"				
	3							
						42"		
						Dark orange brown f gravelly c-f SAND w tr. silt (SW) 48"		
	4					SAA w some f. gravel & some silt (SM)		
	5							
						72"		
	6			34"		Very dark gray-black, silty CLAY/ clayey SILT w tr. c. sand & f. gravel highly organic (OH/OL)		
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/24/00
DATE COMPLETED: 2/24/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy env.

F-188

AR324461

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	8					SAA _ _ _ _ _ 96" Orange brown c-f SAND w̄ some f. gravel & tr. silt (SW)		
	9					108" Orange brown c-f sandy F. GRAVEL w̄ tr. silt (GM)		
	10	24"				120" Very dark gray, clayey SILT w̄ tr. c. sand, highly organic (OL)		
	11							
	12					144" END of SAMPLE @ 12'		

PROJECT NO.:_____
DATE BEGAN:_____
DATE COMPLETED:_____
FIELD GEOLOGIST:_____
CHECKED BY:_____

GWL: DEPTH ____ DATE/TIME _____
GWL: DEPTH ____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324462

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-10A

1/1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

DESCRIPTION

Brown, SILT w̲ tr. f. gravel, c-f sand, & clay, w̲ organics (MH)

————— 10"

Orangebrown, silty m-f SAND w̲ tr. c. sand & f. gravel (SM)

Recovery: 40"

————— 36"

Orangebrown, c-f SAND w̲ tr. f. gravel & silt (SW)

————— 48"

SAA w̲ some silt

Recovery: 24"

————— 60"

blackish gray, clayey SILT w̲ tr. c-f sand & f. gravel, with organics (OL) 72"

END of SAMPLE @ 6'

Depths: 1, 2, 3, 4, 5, 6

REMARKS: refusal at 6ft concrete in shoe

AR324463

PROJECT NO.: Newport SLF
DATE BEGAN: 2/24/00
DATE COMPLETED: 2/24/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4ft sleeves.

NOTES:
driller: Hardy Env.

F-188

BORING NO.

LOG OF BORING NO. GS-10

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 621914.4 E 602349.3
SURFACE EL: _____

Depth 1–4: Sample Recovery 40"

Depth 6: Sample Recovery 36"

Description:
Brown, SILT w̲ tr. f. gravel c. f sand 3 clay, organics (MH)
_ _ _ 12"

Orange brown silty m-f SAND w̲ tr. f. gravel 3 c sand (SM)
_ _ _ 36"

Orange brown c-f SAND w̲ tr. f. gravel 3 silt (SW)
_ _ _ 48"

SAA w̲ some silt
_ _ _ 72"

Blackish gray, clayey SILT, w̲ tr. f. gravel (rock fragments) high organic content (OL)

PROJECT NO.: Newport SLF
DATE BEGAN: 2/24/00
DATE COMPLETED: 2/24/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH ____ DATE/TIME ____
GWL: DEPTH ____ DATE/TIME ____
DRILLING METHOD: ____
Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.

AR324464

F-188

BORING NO.

LOG OF BORING NO. GS-10

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

DESCRIPTION

SAA

_____ _____ 96"

Orange brown, c-f SAND w̲ some f. gravel & tr. silt

(SW)

120"

Dark gray, clayey SILT w̲ tr. c. sand & f. gravel, organics

(OL)

144"

END of BORING @ 12'

Depth markings: 8, 9, 10, 11, 12, 13

AR324465

F-188

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-11

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N 621961.3 E 602190.9 SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	1					Orange brown, clayey SILT/ silty CLAY w tr. f.gravel, c-f sand & organics		
	2			46"				
	3							
	4							
	5							
	6			40"				
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.

AR324466

F-188

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-11

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

DESCRIPTION

SAA

_ _ _ _ 98"

SAA

_ _ _ _ 106"

Brown, silty CLAY/clayey SILT w̲ some c.-f sand & tr. f. gravel & ~~no~~ brick fragments

(CL/CH)

_ _ _ _ 132"

Blackish Gray, silty CLAY w̲ very high organic content

(OH)

_ _ _ _ 144"

SAA w̲ tr. m.-f. sand

& Blackish gray, orange brown, gray, & greenish gray in color high organic content

Depth markers: 8, 9, 10, 11, 12, 13, 14

Sample recovery: 40"

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324467

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-11

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
	-15- -16-					— 3" thick layer of silty, clayey f. SAND ___ 180" Gray, silty CLAY ≈ high organic content. END of SAMPLE @ 16'		

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
_____
_____

NOTES:

AR324468

F-188

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-12

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES: N 622014.8 E 602128.8
SURFACE EL: _____

DESCRIPTION:

Brown, clayey SILT w/ high organic content (MH) ___ 3"

Orange brown, silty m-f SAND w/ some c. sand (SM)

___ ___ ___ ___ ___ 24"

Brown & gray, silty f. SAND/ f. sandy SILT w/ some tr. clay tr. m. sand (SM/ML)

___ ___ ___ ___ 48"

Brown, silty f. SAND w/ tr. c-m sand (SM)

___ ___ ___ ___ 60"

Brown-gray, f. sandy SILT/clayey SILT w/ tr m-c sand & f. gravel (ML/CL)

Sample recovery: 40", 40"

Depth scale 1–7 feet

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH ____ DATE/TIME ____
GWL: DEPTH ____ DATE/TIME ____
DRILLING METHOD: Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.

AR324469

F-188

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-12   2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	8					SAA 96" END of SAMPLE @ 8'		

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324470

F-188

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-13

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES

N 621964.1 E 602021.3

SURFACE EL: _____

DESCRIPTION

Brown clayey SILT w̲ organics (MH) — 2"

Light orangebrown silty m-f SAND (SM)

— layer of grey silty CLAY (2")

— layer of grey silty CLAY (1")

36"

Gray silty CLAY w̲ some orangebrown silty m-f sand tr. organics (OH) 48"

Light brown, silty f. SAND w̲ tr. m. sand (SM)

72"

Dark gray clayey SILT w̲ high organics w̲ light gray m-f sand layers <1/4" thick ≈ 5 per foot (OL)

Sample recovery: 28", 36"

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.

AR324471

F-188

LOG OF BORING NO. GS-13

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES

N _____ E _____

SURFACE EL: _____

DESCRIPTION

SAA

96"

8

9

No sample taken 8-10 ft

24"

10

Dark brown, silty CLAY tr. organics (CH/OH)

132"

11

Gray, silty f. SAND tr. m. sand (SM)

24"

12

13

14

END of SAMPLE @ 14' 168"

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324472

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-14

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 621979   E 601916.1
SURFACE EL: _____

DESCRIPTION

Brown, silty CLAY w/ organics 4"
(MH)

Dark brown clayey SILT w/ some f. sand tr. m.sand & f. gravel (ML)

40"   (at depth ~2)

36"   (at depth ~3)

Brown - lt. brown, silty f. SAND f. ~~sandy~~ sandy SILT tr. clay & m. sand. (ML/SM)

48"

SAA

60"

Dark Gray, clayey SILT tr. f. sand ~~organic~~ organic & micaceous (OL)

40"   (at depth ~6)

84"

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH ____ DATE/TIME ____
GWL: DEPTH ____ DATE/TIME ____
DRILLING METHOD: _____

NOTES:

AR324473

F-188

BORING NO

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-14

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	8					Brownish gray, silty m-f SAND tr c.sand & clay (SM) 96" END of SAMPLE @ 8'		
	9							
	10							
	11							
	12							
	13							

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
_____
_____

NOTES:

AR324474

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-15

½

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES

N 621981.9   E 601770.2

SURFACE EL: _____

DESCRIPTION

Orange brown - Brown SILT ⊻ tr. clay & high organic content (MH)   12"

Brown, clayey SILT ⊻ tr. m-f. sand (ML)

40"

30"

Dark gray, silty CLAY ⊻ high organic content (OH)

48"

Brown f. sandy SILT ⊻ some clay (ML/OL)

72"

24"

Dark gray, silty CLAY ⊻ some f. sand & organic content (OH)

Depth markers: 1, 2, 3, 4, 5, 6, 7

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4ft sleeves

NOTES: driller: Hardy Environ.

AR324475

F-188

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-15

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	8					SAA 46" END of SAMPLE @ 8'		

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324476

F-188

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-16

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N 621922.3 E 601698 — SURFACE EL: _____		
	1					Brown – orange brown, f. sandy SILT w some clay & organic content (MH) 12"		
	2			46"		Brown – gray, clayey SILT w. tr. c.-f. sand, micaceous & with organic content (ML/MH)		
	3							
	4					— — — 48 — SAA		
	5							
	6			24"		— — — 72" —		
	7					Gray silty m.-f SAND tr. c. sand & clay (SM)		

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy Environmental

AR324477

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-16

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						COORDINATES N _____ E _____ SURFACE EL: _____		
						SAA		
	8					END of SAMPLE @ 8' 92"		

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
_____
_____

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-17

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 621943.1 E 601608.1
SURFACE EL: _____

DESCRIPTION

Dark Brown, SILT w/ tr. clay & c-f. sand organic (MH) ___ 6"

Dark grey, ≈ rust brown, clayey SILT w/ organics (OL)

18" (at depth 2)

___ ___ ___ 48"

Dark Brown - Dark Gray, m-f sandy SILT w/ tr. organics (ML)

___ 72"

32" (at depth 6)

Dark grey, clayey SILT w/ high organic content (OL)

Depth markings: 1, 2, 3, 4, 5, 6, 7

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4 ft. sleeves

NOTES:
driller: Hardy env.

AR324479

F-188

BORING NO.
SHEET OF

LOG OF BORING NO. GS-17

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

DESCRIPTION

SAA

96"

END of Sample @ 8'

(depth 8)

PROJECT NO.: _____
DATE BEGAN: _____
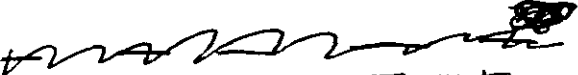DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324480

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-19

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N 621951.5 E 601463.9 SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	1					Orangebrown, silty mf SAND ≃ tr. c. sand & f. gravel (SM) ≃ tr. organics		
	2			44"		___ ___ 24" Brown, clayey SILT ≃ tr. c-f sand & f. gravel (ML)		
	3							
	4					___ ___ ___ ___ SAA		
	5							
	6			5"				
	7							

PROJECT NO.: Newport 5LF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.

AR324481

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. 65-19

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

	8			40"		SAA ___ ___ ___ 96" SAA w Barite Ore Waste		
	9							
	10					120" Dark gray, silty CLAY w organics (OH)		
	11							
	12					144" END of SAMPLE @ 12'		
	13							
	14							

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324482

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-20▮

1/1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N 621998.2 E 601360.1 — SURFACE EL: ____		
	1			46"		Dark Brown, SILT ≃ tr. f. gravel & c-f sand, organic content (MH) ≃ tr. clay. 8"		
						Brown - redish brown, SILT ≃ some clay & organics, tr. c-f sand (silt) (ML/MH)		
	2					30"		
	3					Black, clayey SILT ≃ tr. f. gravel (ML) (Barite Ore Waste)		
	4					48" END of SAMPLE @ 4'		
	5							
	6							
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH ____ DATE/TIME ____
GWL: DEPTH ____ DATE/TIME ____
DRILLING METHOD: Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.

AR324483

F-188

Field Log

LOG OF BORING NO. GS-20A

1/1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N 621973.9 E 601380.7 SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	1			46"		Brown, silty CLAY w̅ tr C-F sand & organic content (MH) 12"		
	2					Brown, gray, red brown, tan, mixed colored clayey SILT w̅ tr m-f sand (CL/ML)		
	3					36"		
	4					Black clayey SILT w̅ tr.f. sand (CL/ML) (Barite Ore waste) 48" END OF SAMPLE @ 4'		
	5							
	6							
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kabl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4ft sleeves

NOTES:
driller: Hardy Environ.

AR324484

F-188

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-20B

1/1

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N 621955.1 E 601354.7 SURFACE EL: _____		
	1			46"		Brown, clayey SILT w̄ organics (MH) 6" Brown, tan, gray, & red brown mixed colored, clayey SILT, layered (ML)		
	2							
	3					30" Black, clayey SILT w̄ tr. f. sand & f. gravel (ML) (Barite Ore Waste) 48"		
	4					END of SAMPLE @ 4'		

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GW: DEPTH _____ DATE/TIME _____
GW: DEPTH _____ DATE/TIME _____
DRILLING METHOD: Geoprobe w/ 4 ft sleeve

NOTES:
driller: Hardy Env.

F-188

LOG OF BORING NO. GS-20C

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						COORDINATES N 621937.4 E 601357.7 SURFACE EL: _____		
						DESCRIPTION		
	1			18"		Brown, clayey SILT w organics tr. f-c sand (MH) 6"		
	2					Brown, tan, w white & black mixed colored, clayey SILT w tr. f. sand (ML)		
	3							
	4					48" Black - dark gray, silty F. SAND (SM) (Barite Ore Waste)		
	5			36"		60" Black - dark gray, clayey SILT w tr. f. sand (Barite Ore Waste)		
	6							
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/29/00
DATE COMPLETED: 2/29/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe 4/4 ft sleeve

NOTES:
driller: Hardy Env.

AR324486

F-188

BORING NO.
SHEET OF

LOG OF BORING NO. GS-20C   2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						COORDINATES N ___ E ___ SURFACE EL: ___		
	8					96″ END of SAMPLE @ 8′		

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH ___ DATE/TIME ___

GWL: DEPTH ___ DATE/TIME ___

DRILLING METHOD: _____

NOTES:

AR324487

The W-C Diamond Group
A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-21

1/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						COORDINATES N 621968.3 E 601298.3 SURFACE EL: _____		
	1					Brown, clayey SILT w/ organics (MH) 6" Gay, brown, red brown, tan, clayey SILT (ML)		
	2							
	3							
	4					48" ~~END OF SAMPLE~~ with Black, clayey SILT, highly organic (Barite ore Waste) (ML)		
	5					54" Dark gray silty vf-f. SAND (SM) 60"		
	6					Dark gray - gray, clayey SILT, organic & micaceous (ML/OL) with Barite ore Waste		
	7							

PROJECT NO.: _Newport SLF_
DATE BEGAN: _2/29/00_
DATE COMPLETED: _2/29/00_
FIELD GEOLOGIST: _R. Kahl_
CHECKED BY: _T. Campbell_

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4ft sleeves

NOTES:
driller: Hardy Environmental

AR324488

F-188

The W-C Diamond Group

A Division of URS Corporation

Field Log

LOG OF BORING NO. GS-21

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	8					SAA		
						96"		
						END of SAMPLE @ 8'		

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH ____ DATE/TIME ____

GWL: DEPTH ____ DATE/TIME ____

DRILLING METHOD: _____

NOTES:

AR324489

F-188

BORING NO.
SHEET OF

LOG OF BORING NO. GS-22   1/3

ELEV. (FEET M.S.L)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 622093.4   E 601302.3
SURFACE EL: _____

Bluish gray, silty f. GRAVEL (GM)
— — — — 12"

Brown, clayey SILT w
tr. c-f. sand & f. gravel (ML)

— — — — 48"

Brown, SILT w some
clay & tr c-f. sand &
f. gravel (MH)

Depth markings: 1, 2, 3, 4, 5, 6, 7

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-22

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	8					SAA		
						——— ——— ——— 96"		
						SAA		
	9					——— ——— ——— 108"		
	10					Gray, clayey SILT w̄ tr. c-f sand & f. gravel, tr. organics (OL/ML/CL) (Possible trace of Barite ore waste)		
	11							
						138"		
	12					Brown silty f. SAND w̄ organics (SM) ——— 144"		
						SAA, w̄ tr. Barite Ore Waste		
	13							
	14							

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH ____ DATE/TIME _____
GWL: DEPTH ____ DATE/TIME _____
DRILLING METHOD: _____
_____

NOTES:

AR324491

F—188

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-22

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
	15					SAA		
	16					192"		
						END of SAMPLE @ 16"		

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
_____

NOTES:

AR324492

F-188

LOG OF BORING NO. GS-22A

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 6220505 E 6012732
SURFACE EL: _____

Greenish Gray, silty f. GRAVEL w some c-f sand (GM)

24"

Orange brown, f. sandy SILT w tr. clay, c-m. sand & f. gravel (ML)

36"

Red brown, silty CLAY/ clayey SILT w tr. c-f sand & f. gravel (ML/CL) 48"

Brown, clayey SILT w tr. c-f sand & f. gravel (CL/ML)

Depth markings: 1, 2, 3, 4, 5, 6, 7

PROJECT NO.: Newport SLF
DATE BEGAN: 2/28/00
DATE COMPLETED: 2/28/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4 ft sleeves

NOTES:
driller: Hardy Env.

AR324493

F-188

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. 6S-22A

2/2

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		

DESCRIPTION

SAA

— — — — 96"

Gray f. sandy SILT
w/ some clay   (M2)

— — — — — 120"

Dark gray, silty CLAY
~ tr. f. sand with high
organic content   (O4)

END of SAMPLE @ 12'

Depth markings: 8, 9, 10, 11, 12, 13, 14

NOTES:

AR324494

F-188

BORING NO.

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-22B

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N 622014.5 E 601246
SURFACE EL: _____

DESCRIPTION

Greenish Gray, silty F. GRAVEL w̲ some c-f sand (GM)

24"

Orange Brown, c-f sandy SILT w̲ some f. gravel (ML)

30"

Brown - red brown, clayey SILT w̲ tr. c-f sand & f. gravel (ML)/(CL)

48"

SAA

78"

Red Brown, silty CLAY w̲ some m-f sand (CL/CH)

Depth markers: 1, 2, 3, 4, 5, 6, 7

PROJECT NO.: Newport SLF
DATE BEGAN: 2/28/00
DATE COMPLETED: 2/28/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: T. Campbell

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____
Geoprobe w/ 4ft sleeves

NOTES:
driller: Hardy Env.

AR324495

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-22B

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

Depths shown: 8, 9, 10, 11, 12, 13, 14

— layer of orange-brown silty f. SAND
≈ 1" thick   96"

* missing sample

Dark gray-brown, silty m.f. SAND
w some f. gravel & tr. c. sand
(SM)   156"

Dark greenish gray, clayey SILT
organic   (OL/OH)

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324496

F-188

BORING NO.
SHEET   OF

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. _GS-22B_

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	15'					SAA		
	16'					END of SAMPLE @ 16' 192"		

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

NOTES:

AR324497

F-188

BORING NO.
SHEET OF

LOG OF BORING NO. GS-22C   1/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N 621972.9 E 601216.4 SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	1					Blueish Gray, silty f GRAVEL ~ some c-f. sand (GM) - layer of rock fragments (<1") 12"		
	2					Brown-Gray, clayey SILT w tr c-f. sand & f.gravel (ML)		
	3							
	4					— — — — 48"		
	5					SAA		
	6							
	7							

PROJECT NO.: Newport SLF
DATE BEGAN: 2/28/00
DATE COMPLETED: 2/28/00
FIELD GEOLOGIST: R. Kahl
CHECKED BY: I. Campbell

GWL: DEPTH ____ DATE/TIME ____
GWL: DEPTH ____ DATE/TIME ____
DRILLING METHOD: ____
Geoprobe w/ 4 ft sleeves

NOTES:

AR324498

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

Field Log

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

DESCRIPTION

SAA

— — — — — 96"

Gray ≃ some brown, clayey SILT, organic

(OL)

— — — — — 120"

Gray ≃ brown, silty CLAY ≃ pockets of clayey SILT, ≃ some organics, micaceous

(OH/OL)

Depths: 8, 9, 10, 11, 12, 13, 14

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324499

F-188

BORING NO.
SHEET OF

LOG OF BORING NO. GS-22C

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES N _____ E _____ SURFACE EL: _____ DESCRIPTION	USCS SYMBOL	REMARKS
	15					SAA		
	16					142" END of SAMPLE @ 16'		

PROJECT NO.: _____

DATE BEGAN: _____

DATE COMPLETED: _____

FIELD GEOLOGIST: _____

CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____

GWL: DEPTH _____ DATE/TIME _____

DRILLING METHOD: _____

NOTES:

AR324500

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-22 D   1/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						COORDINATES N 621935.1 E 601188.1 SURFACE EL: _____		

DESCRIPTION

Blueish gray, silty f. GRAVEL
w/ c-f sand   (GM)
^ some

_____ _____ 12"

Brown - Grey, clayey SILT
w/ organics
(CL/ML/OL)

_____ _____ 48"

SAA, micaceous w/ tr
c-f. sand

Depth scale marks: 1, 2, 3, 4, 5, 6, 7

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. 6S 22 D   2/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS

COORDINATES
N _____ E _____
SURFACE EL: _____

DESCRIPTION

SAA

— — — — 96"

SAA

— Thin layer of fine gravel (<1") 120"

Grey - Dark grey, Silty CLAY / clayey SILT w organics (OL/OH)

— — — 144"

SAA w tr. F. gravel & c-f. sand.

Depth markings: 8, 9, 10, 11, 12, 13, 14

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324502

F-188

BORING NO.
SHEET OF

The W-C Diamond Group
A Division of URS Corporation

LOG OF BORING NO. GS-22D

3/3

ELEV. (FEET M.S.L.)	DEPTH (FEET)	SAMPLE NO. AND TYPE	BLOWS PER 6-INCH INCREMENTS	SAMPLE RECOVERY (IN.)	PROFILE	COORDINATES / DESCRIPTION	USCS SYMBOL	REMARKS
						N _____ E _____ SURFACE EL: _____		
	15					SAA		
	16					196" END of SAMPLE @ 16'		

PROJECT NO.: _____
DATE BEGAN: _____
DATE COMPLETED: _____
FIELD GEOLOGIST: _____
CHECKED BY: _____

GWL: DEPTH _____ DATE/TIME _____
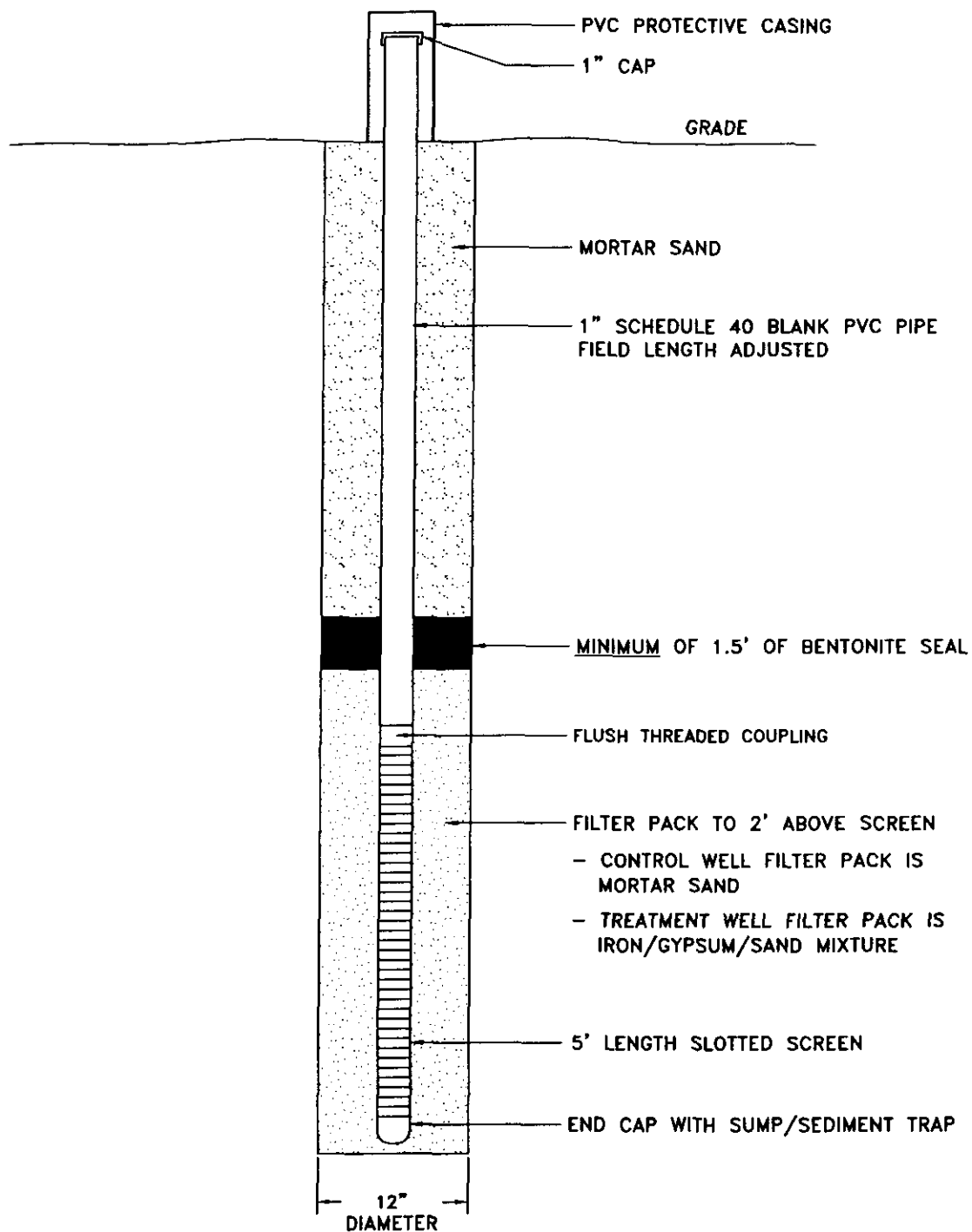GWL: DEPTH _____ DATE/TIME _____
DRILLING METHOD: _____

NOTES:

AR324503

F-188

BORING NO.
SHEET OF

APPENDIX C.2

PERMEABLE REACTIVE BARRIER
IN SITU TEST BORING RESULTS

PVC PROTECTIVE CASING

1" CAP

GRADE

MORTAR SAND

1" SCHEDULE 40 BLANK PVC PIPE
FIELD LENGTH ADJUSTED

MINIMUM OF 1.5' OF BENTONITE SEAL

FLUSH THREADED COUPLING

FILTER PACK TO 2' ABOVE SCREEN

- CONTROL WELL FILTER PACK IS
  MORTAR SAND

- TREATMENT WELL FILTER PACK IS
  IRON/GYPSUM/SAND MIXTURE

5' LENGTH SLOTTED SCREEN

END CAP WITH SUMP/SEDIMENT TRAP

12"
DIAMETER

DUPONT

Corporate Remediation Group
An Alliance between
DuPont and The W-C Diamond Group

Barley Mill Plaza, Building 27
Wilmington, Delaware 19880-0027

PERMEABLE REACTIVE BARRIER
TEST BORING

DuPont Newport Facility
Newport South Landfill
Newport, Delaware

SCALE	DESIGNED	DRAWN	CAD FILE NO.
-		DEL	7105A001
DATE 6/27/00	CHECKED WRK	APPROVED	FIGURE C.4

Table C.1
Simulated Wall Life Calculations
Permeable Reactive Barrier Field Tests
Newport Superfund Site, Newport, Delaware

Case	Cumulative Field Test Flow	Case Wall Flux	Simulated Wall Life
	Liters	cm^3/cm^2/day	Years
Zinc Treatment/Control			
Current Conditions (3' of soil)	374	1.24	0.052 (19 days)
Asphalt (4") and Stone (8")	374	0.0207	3.1
Soil (18") and Bentomat	374	0.00413	16
Topsoil (6") and Clay (12")	374	0.000413	157
Topsoil (6"), Fill (12"), Drainage Layer, and Synthetic Layer	374	0.0000103	6293
Barium Treatment/Control			
Current Conditions (3' of soil)	297	1.24	0.042 (15 days)
Asphalt (4") and Stone (8")	297	0.0207	2.5
Soil (18") and Bentomat	297	0.00413	12
Topsoil (6") and Clay (12")	297	0.000413	125
Topsoil (6"), Fill (12"), Drainage Layer, and Synthetic Layer	297	0.0000103	4997

Simulated wall life is calculated using the following equation:

$$\text{wall life, years} = \frac{(1000 F_t / A_t)}{(CWF)365}$$

where F_t is the cumulative field test flow in liters, A_t is the test flux area in cm², and CWF is the case wall flux for five different cap materials in cm³/cm²/day.

The test flux area is a cylinder with a length equal to the screened length of the well and a radius at the mid-point between the well screen and the bore hole radius. The ends of the cylinder are assumed to be impermeable and therefore not to contribute to the flux area. Thus the area is

$$A_t = 2\pi R_t L$$

where R_t is the midpoint between the well screen and the bore hole in cm and L is the screened length of the well in cm. For the simulated wall life calculations, the test flux area is

$$A_t = 2\pi(16.5cm)(152.4cm) = 15800cm^2$$

Table C.2
Zinc-rich Test Wells - Dissolved Metals
Permeable Reactive Barrier Field Tests
Newport Superfund Site, Newport, Delaware

ZC

Analyte	Units	5/15	5/16	5/18	5/19	5/22	5/23	5/24	5/25	5/26	5/30	5/31	6/1	6/2	6/9	6/13
Barium	mg/L	196	194	224	219	161	133	139	143	180	198	225	227	230	231	145
Zinc	mg/L	0.0154 J	0.0069 J	ND	0.009 J	0.0105 J	0.0074 J	ND	ND	0.0142 J	0.0065 J	0.0102 J	ND	ND	ND	ND
Cadmium	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	2.65	NA	3.44	8.24	28.7	26.7	28.6	22.2	16.5	9.8	13.2	12.3	12.2	22.1	34
Copper	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	mg/L	0.206	0.081	0.111	0.16	1.73	1.39	1.58	0.67	0.58	0.105	0.268	0.199	0.279	ND	0.963
Nickel	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ZT

Analyte	Units	5/15	5/16	5/18	5/19	5/22	5/23	5/24	5/25	5/26	5/30	5/31	6/1	6/2	6/9	6/13
Barium	mg/L	0.16	0.18	0.22	0.23	0.32	0.34	0.33	0.29	0.32	0.49	0.54	0.26	0.32	0.357	0.364
Zinc	mg/L	ND	0.0059 J	ND	ND	ND	ND	ND	ND	ND	0.0056 J	0.0047 J	ND	ND	ND	ND
Cadmium	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	587	NA	638	606	564	669	623	600	627	634	612	589	627	612	640
Copper	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	mg/L	0.352	0.38	0.473	0.75	0.361	0.597	0.619	0.463	0.829	0.129	0.315	0.356	0.578	0.0448	ND
Nickel	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

- **ND** Not detected
- **NS** Not sampled
- **NA** Not analyzed
- **J** Result was between the minimum detection limit and the practical quantitation limit
- **ZT** Treatment well in zinc-rich area (100:20:5 mortar sand to gypsum to iron ratio by weight)
- **ZC** Control well in zinc-rich area

prepared by W.R. Kahl, 6/9/00

checked by P. Karakelian, 6/10/00

Table C.3
Barium-rich Test Wells - Dissolved Metals
Permeable Reactive Barrier Field Tests
Newport Superfund Site, Newport, Delaware

BC

Analyte	Units	5/15	5/16	5/17	5/19	5/22	5/23	5/24	5/25	5/26	5/30	5/31	6/1	6/2	6/9	6/13
Barium	mg/L	44.5	62.4	55.6	69	71.9	84.3	74.7	92.3	83.5	103	93.4	90.8	86.4	84.7	94.8
Zinc	mg/L	0.0101 J	0.0060 J	0.0047	0.0057 J	ND	0.0099 J	0.0077 J	ND	0.0086 J	0.0066 J	0.0096 J	0.047	0.0079 J	0.0093 J	ND
Cadmium	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	13.1	NA	NA	14.1	13.3	15.2	14	13.8	15.1	13.2	15.1	18.1	15	12.5	13.7
Copper	mg/L	ND	ND	ND	ND	ND	0.0137 J	ND	ND	ND	ND	0.0036 J	ND	ND	ND	ND
Manganese	mg/L	1	0.888	0.921	0.962	1.23	1.19	1.27	0.875	1.4	0.831	1.86	1.79	1.98	1.64	1.46
Nickel	mg/L	ND	ND	ND	ND	ND	0.0385 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

BT

Analyte	Units	5/15	5/16	5/17	5/19	5/22	5/23	5/24	5/25	5/26	5/30	5/31	6/1	6/2	6/9	6/13
Barium	mg/L	0.0353 J	0.0112 J	0.0419 J	0.0482 J	0.0476 J	0.0497 J	0.0358 J	0.0423 J	0.0481 J	0.0437 J	0.0512 J	0.0447 J	0.0421 J	0.0587 J	0.0413 J
Zinc	mg/L	0.0083 J	0.0065 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	542	NA	NA	506	507	537	550	516	502	505	533	494	469	540	509
Copper	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	mg/L	13.3	14.8	17.1	16.2	15.9	16.7	16	15.3	14.7	15.2	12.1	13	12.4	10.7	11.6
Nickel	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:
ND   Not detected
NS   Not sampled
NA   Not analyzed
J   Result was between the mininum detection limit and the practical quantitation limit
BT   Treatment well in barium-rich area (100:20:5 mortar sand to gypsum to iron ratio by weight)
BC   Control well in barium-rich area

prepared by W.R. Kahl, 6/9/00
checked by P. Karakelian, 6/10/00

Table C.4
Zinc-rich and Barium-rich Test Wells - Total Metals
Permeable Reactive Barrier Field Tests
Newport Superfund Site, Newport, Delaware

Zinc-rich Test Wells

		ZT							ZC				
	Units	5/19	5/25	6/1	6/9	6/13		Units	5/19	5/25	6/1	6/9	6/13
Barium	mg/L	0.33	0.35	0.31	0.381	0.392		mg/L	221	135	227	218	163
Zinc	mg/L	ND	ND	ND	ND	ND		mg/L	0.0102 J	0.0057 J	ND	0.0089 J	ND
Cadmium	mg/L	ND	ND	ND	ND	ND		mg/L	ND	ND	ND	ND	ND
Calcium	mg/L	635	610	638	615	645		mg/L	3.43	29.1	13.3	21	31.9
Copper	mg/L	ND	0.0070 J	ND	ND	ND		mg/L	ND	ND	ND	ND	ND
Manganese	mg/L	0.528	0.761	0.496	ND	0.136		mg/L	0.405	2.27	1.26	1.58	2.24
Nickel	mg/L	ND	ND	ND	ND	ND		mg/L	ND	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND	ND		mg/L	ND	ND	ND	ND	ND

Barium-rich Test Wells

		BT							BC				
	Units	5/20	5/25	6/1	6/9	6/13		Units	5/20	5/25	6/1	6/9	6/13
Barium	mg/L	0.0492 J	0.0471 J	0.0562 J	0.0894 J	0.0553 J		mg/L	72.6	85	84	81.3	92.9
Zinc	mg/L	ND	ND	ND	ND	ND		mg/L	0.0083 J	ND	ND	ND	ND
Cadmium	mg/L	ND	ND	ND	ND	ND		mg/L	ND	ND	ND	ND	ND
Calcium	mg/L	514	530	486	575	591		mg/L	14.4	14.1	15.2	14.1	14
Copper	mg/L	ND	ND	ND	ND	ND		mg/L	ND	ND	ND	ND	ND
Manganese	mg/L	15.5	15.9	11.7	11.5	11.7		mg/L	1.07	1.26	2.17	2.18	1.69
Nickel	mg/L	ND	ND	ND	ND	ND		mg/L	ND	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND	ND		mg/L	ND	ND	ND	ND	ND

Notes:

ND Not detected
NS Not sampled
NA Not analyzed
J Result was between the minimum detection limit and the practical quantitation limit

Prepared by W.R. Kahl, 6/9/00, checked by P. Karakelian, 6/10/00

ZT Treatment well in zinc-rich area (100:20:5 mortar sand to gypsum to iron ratio by weight)
ZC Control well in zinc-rich area
BT Treatment well in barium-rich area (100:20:5 mortar sand to gypsum to iron ratio by weight)
BC Control well in barium-rich area

AR324509

Table C.5
Barium-rich Test Wells, Zinc-rich Test Wells, and Select Monitoring Wells
Expanded Analytes - Total and Dissolved Metals
Permeable Reactive Barrier Field Test
Newport Superfund Site, Newport, Delaware

		Detection Limit	Units	Barium Control		Barium Treatment		Zinc Control		Zinc Treatment		RDW-7	MW-18A
				6/9	6/13	6/9	6/13	6/9	6/13	6/9	6/13	6/13	6/13
Barium	Dis.	0.085	mg/L	84.7	94.8	0.0587 J	0.0413 J	231	145	0.357	0.364	52	113
Zinc	Dis.	0.0086	mg/L	0.0093 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	Dis.	0.0036	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	Dis.	0.035	mg/L	12.5	13.7	540	509	22.1	34	612	640	19.9	11.9
Copper	Dis.	0.0027	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	Dis.	0.0025	mg/L	1.64	1.46	10.7	11.6	0.481	0.963	0.0448	0.105	0.237	0.953
Nickel	Dis.	0.0084	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	Dis.	0.0019	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	Dis.	0.0012	mg/L	0.0059 J	0.0071 J	0.0016 J	0.0045 J	0.0028 J	0.0035 J	ND	0.0046 J	0.0071 J	0.0038 J
Chromium	Dis.	0.0066	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	Dis.	0.0071	mg/L	0.0229 J	0.0372 J	0.0619	0.05 J	0.0192 J	0.0194 J	ND	ND	0.0244 J	0.053
Iron	Dis.	0.0067	mg/L	0.0777 J	0.0317 J	11.3	12.4	0.0254 J	0.0634 J	0.1	0.0816 J	0.763	0.404
Magnesium	Dis.	0.018	mg/L	2.15	2.01	17.1	13	2.52	3.76	2.44	2.78	2.9	2.84
Mercury	Dis.	0.00004	mg/L	0.000079 J	0.0061	0.000089 J	ND	ND	ND	0.000051 J	0.000081 J	0.000085 J	ND
Potassium	Dis.	0.23	mg/L	25.5 J	27.7	4.28	5.03	11.1	9.22	12.4	11.8	13.1	21
Selenium	Dis.	0.06	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silica	Dis.	0.52	mg/L	57.5	60.1	5	5.3	174	157	94.3	93.3	47.2	135
Sodium	Dis.	0.3	mg/L	25.3	25.2	16.4	16.5	13	17.5	16.6	16.5	48.1	30.8
Vanadium	Dis.	0.0026	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	Total	0.085	mg/L	81.3	92.9	0.0894 J	0.0653 J	218	163	0.381	0.392	69.2	124
Zinc	Total	0.0086	mg/L	ND	ND	ND	ND	0.0089 J	ND	ND	ND	0.209	ND
Cadmium	Total	0.0036	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	Total	0.035	mg/L	14.1	14	575	591	21	31.9	615	645	19.3	11
Copper	Total	0.0027	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	Total	0.0025	mg/L	2.18	1.69	11.5	11.7	1.58	2.24	0.0618	0.136	0.421	0.846
Nickel	Total	0.0084	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	Total	0.0019	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.117	ND
Arsenic	Total	0.0012	mg/L	0.0069 J	0.007 J	0.0016 J	0.0046 J	0.0024 J	0.0036 J	ND	0.0045 J	0.0107	0.0039 J
Chromium	Total	0.0066	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	Total	0.0071	mg/L	0.0274 J	0.035 J	ND	ND	0.0636	0.0517	ND	ND	0.0316 J	0.0562
Iron	Total	0.0067	mg/L	0.352	0.139	12.6	17.3	0.881	2.78	0.152	0.209	4.5	0.631
Magnesium	Total	0.018	mg/L	2.81	2.17	20	16.5	2.44	3.4	0.0971 J	0.1	3.12	2.48
Mercury	Total	0.00004	mg/L	0.000049 J	0.000089 J	0.000075 J	ND	ND	ND	ND	ND	ND	0.000082 J
Potassium	Total	0.23	mg/L	26.9	27.1	4.3	4.56	10.5	9.31	12.5	11.7	14	21.2
Selenium	Total	0.06	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	Total	0.3	mg/L	28.6	26.8	17.9	17	14.2	18.8	17.1	14	49.5	29.5
Vanadium	Total	0.0026	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia	Total	0.15	mg/L	2.52	2.2	0.452 J	ND	0.527 J	0.56 J	ND	0.53 J	1	2.8
Chloride	Total	6	mg/L	63.1	43.4	43.4	39.3	32.4	30.3	43.4	43.8	98.9	44.5
Sulfate	Total	1.5	mg/L	69.7	1350	1350	1250	11.8	10.6	1470	1450	ND	7.11
Sulfide	Total	0.53	mg/L	8.03	4.07 J	7.9	9.3	14.8	12.9	13.1	13.9	6.5	33.1
Total Cyanide	Total	0.004	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TSS	Total	4.1	mg/L	32	23.6	32	23.6	16.8	34	16.8	23.6	33.6	ND

ND Not detected

J   Result was between the minimum detection limit and the practical quantitation limit

ZT Treatment well in zinc-rich area (100:20:5 mortar sand to gypsum to iron ratio by weight)

ZC Control well in zinc-rich area

BT Treatment well in barium-rich area (100:20:5 mortar sand to gypsum to iron ratio by weight)

BC Control well in barium-rich area

prepared by W. R. Kahl, 7/5/00
checked by M. M. Thomson, 7/6/00

APPENDIX C.3

REDOX INVESTIGATION

Table C.6
Test Borings - Field Parameters
Permeable Reactive Barrier Field Tests
Newport Superfund Site, Newport, Delaware

Boring ID	Temp. (C)	pH	Redox (mV)	DO (mg/L)
BC	17.5	9.8	-108.85	0.00
BT	17.6	7.9	-128.35	0.00
ZC	17.1	7.3	-130.70	0.68
ZT	16.0	10.7	-235.85	0.00
MW-23A	14.5	6.4	277.4	0
See Figure C.1 for locations.				

APPENDIX D

SOUTH LANDFILL TREATMENT AND MONITORING SYSTEMS
COST ESTIMATES

NEWPORT SUPERFUND SITE
NEWPORT, DELAWARE

Prepared for:

DuPONT CORPORATE REMEDIATION GROUP
WILMINGTON, DELAWARE

Prepared by:

URS GREINER WOODWARD CLYDE GROUP CONSULTANTS, INC.
282 DELAWARE ANVENUE
BUFFALO, NEW YORK 14202

APRIL 2000

PERMEABLE REACTIVE WALL ESTIMATE

NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
PERMEABLE REACTIVE WALL

Description	Quantity	Unit	Unit Cost	Total Cost
Site Preparation	16	Acre	$ 12,300	$ 196,800
Permeable Reactive Wall				
Iron Filings - 5%	300	Ton	$ 400	$ 120,000
Gypsum - 20%	1,200	Ton	$ 22	$ 26,400
Bio-Slurry	27,000	SF	$ 1.50	$ 40,500
Sand	4,500	Ton	$ 9.30	$ 41,850
Mixing & Placing Wall	27,000	SF	$ 6.40	$ 172,800
Subtotal				$ 401,550
	1	**SF**	**$ 14.87**	**$ 401,550**
Slurry Wall				
Bentonite	135	Ton	$ 135	$ 18,225
Common Fill	2,700	CY	$ 11.25	$ 30,375
Mixing & Placing Wall	21,800	SF	$ 4.60	$ 100,280
Subtotal				$ 148,880
	1	**SF**	**$ 6.83**	**$ 148,880**
Landfill Cap - bentonite mat, 12" of cover soil, 6" of topsoil	16	Acre	$ 77,255	$ 1,236,080
Riverbank Protection	2,000	CY	$ 58.45	$ 116,900
Road Crossings	2	Each	$ 1,000	$ 2,000
Cap Tie-in to Old Airport Road	300	CY	$ 54.96	$ 16,488
Direct Cost Subtotal				$ 2,118,698
General Conditions	100%	Lump Sum	Nec.	$ 250,000
Main Office Overhead	7.7	Percent	$ 2,118,698	$ 163,140
Profit	10	Percent	$ 2,118,698	$ 211,870
Engineering and Project Support	7	Percent	$ 2,118,698	$ 148,309
Monitoring and Maintenance	100%	Lump Sum	Nec.	$ 25,000
Subtotal			$ 3,027,404	$ 3,027,404
Contingency	5	Percent		$ 151,370
TOTAL				**$ 3,178,775**

NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
PERMEABLE REACTIVE WALL

Assumptions:

Permeable Reactive Wall (PRW) = 27.000 sf - ref. attached calcs.

Slurry Wall (SW): 1.450 lf*15' deep*3' thick => 65.250 cf or 2,417 cy. SAY 2.450 cy

Gypsum cost => $0. ref. John Wilkens 12/1/99 e-mail & William Lacy Gray, Jr. Letter dated 2/11/00

Deliver gypsum => $22/Ton. ref. John Wilkens 12/1/99 e-mail & William Lacy Gray, Jr. Letter dated 2/11/00

Gypsum => 5,600 Tons*20% = 1,120 Tons,   Say 1.200 Tons, 20% - ref. 3/15/00 team meeting minutes

Iron Filings => Use 280 Tons. Say 300 Tons, ref. URS backup

Iron Filings => Use $400/Ton. ref. URS backup & Peerless letter dated 4/7/00, use 5% iron filings, ref. Brandt Butler 2/16/00 e-mail

PRW Volume => 81.000 CF / 27 cf per cy = 3,000 CY

Sand (PRW) volume => Use 4.500 ton per attached URS backup, sand cost is $9.30/ton per Nancy Griskowitz, 2/24/00

The Landfill Cap consists of a bentonite mat, 12" of cover soil, and 6" of topsoil

> The cap costs identified in the URS backup are for the cap components only. The cap unit cost is increased by 51% to include the remaining closure components, e.g.: surficial drainage features/structures (swales/downchutes), perimeter drainage (channels and/or pipes), gas collection system (vents and geocomposite/sand), perimeter fencing, access roads, etc. This is consistent with the URS North Landfill Closure estimate ($ 51,162 x 151% = $ 77,255

Assume $25,000 per year per Brandt Butler telecon 4/20/00

Main Office Overhead @ 7.7% is from 2000 Means (Heavy Construction)

Engineering and Project Support: use 7% per URS average for work of this nature

Profit is assumed to be 10%

A 5% contingency has been added at the discretion of the estimator

All manpower, equipment, unit costs, productivity, quantities, etc. have been discussed with and verified by Geo-Con

PERMEABLE REACTIVE WALL

Current Prevailing Labor/Wage Rates – New Castle County, Delaware

	Hrly. Base Rate	PT & I	Loaded Hrly. Rate
Labor Forman	$25.68	35%	$34.67
Laborer	$24.58	35%	$33.18
Operating Engineer	$34.76	35%	$46.93
Truck Driver	$22.10	35%	$29.84

Truck Rental Rates

	2000 Means	Monthly rate	÷	hr./mo.	=	hrly. rate	+	hrly. op.cost	=	hrly. rate
Concrete Truck	016-406-3300	$9,225/mo	÷	176 hrs.	=	$ 52.50	+	$32.50/hr.	=	$85.00/hr.
Dump Truck	016-408-5250	$3,375/mo	÷	176 hrs.	=	$19.20	+	$17.40/hr.	=	$36.60/hr.
Water Truck	016-420-6900	$700/wk.	÷	40 hrs.	=	$17.50	+	$11.07/hr.	=	$28.57/hr.

Equipment Rental Rates

	2000 Means	Monthly rate	÷	hr./mo.	=	hrly. rate	+	hrly. op.cost	=	hrly. rate
1½ cy Backhoe	016-408-0200	$7,500/mo.	÷	176 hrs.	=	$42.60	+	$26.60/hr.	=	$69.20/hr.
1¾ cy Loader	016-408-4650	$3,650/mo.	÷	176 hrs.	=	$20.75	+	$12.50/hr.	=	$33.25/hr.
150 HP Dozer	016-409-4200	$5,530/mo.	÷	176 hrs.	=	$31.75	+	$17.00/hr.	=	$48.75/hr.
Trash Pump – 4"	016-420-5600	$870/mo.	÷	176 hrs.	=	$5.00	+	$2.00/hr.	=	$7.00/hr.

PERMEABLE REACTIVE WALL

Site Preparation

The South landfill site is approximately 16 acres, ref. Nancy Griskowitz e-mail dated 2/3/00

16 acres x 43,560 sf/acre = 696,960 sf

The site contains an earthen, bermed holding cell and a cleared area with stone roads including a parking area. Assume 1/3 of the site has medium trees that will be cut with the stumps chipped and grubbed. Brush hog 1/3 of the site to remove brush and small trees.

Site grading includes collapsing the earthen berms and grading the site to receive a double barrier geosynthetic cap

   2-dozers w/ operators, 1-loader w/ operator, 2-trucks w/ drivers, 1-labor foreman, 2-laborers

696,960 sf ÷ 20,000 sf/day = **35 Days**

Dozer	560 hrs. x $48.75/hr.	=	$27,300
Loader	280 hrs. x $33.25/hr.	=	$9,310
Truck	560 hrs. x $36.60/hr.	=	$20,496
Operator	840 hrs. x $46.93/hr.	=	$39421
Truck Driver	560 hrs. x $28.84/hr.	=	$16,206
Labor Foreman	280 hrs. x $34.67/hr.	=	$9,708
Laborer	560 hrs. x $33.18/hr.	=	$18,851
		Subtotal	$141,022

PERMEABLE REACTIVE WALL

Site Preparation (cont'd.)

2000 Means

Chip Trees	021-104-0200	6 acres x $3,275/ac.	=	$19,650
Grub Stumps	021-104-0250	6 acres x $2,180/ac.	=	$13,080
Brush Hog	021-108-0600	6 acres x $3,094/ac.	=	$18,564
Erosion Control	022-704-1100	3,650 lf x $2.60/lf	=	$ 4,380
			Subtotal	$55,674
		Subtotal, previous page		$141,022
			Total	$196,696 ÷ 16 ac. = ~ $12,293.50 per acre
			SAY	**$12,300 per acre**

PERMEABLE REACTIVE WALL

This estimate is based on the following installation procedure(s) for the permeable reactive wall wall.

- grade permeable reactive wall area

- initiate trench excavation

- mix the bio-slurry in a concrete truck and pump into the trench excavation to stabilize trench sidewalls

- mix the gypsum/iron filings/common fill in the concrete trucks

- displace the bio-slurry with the mixture of gypsum/iron filings/sand using a concrete tremi only after the design invert of the trench has been achieved & verified -- the tremi can be eliminated from the operation once a sloped longitudinal wall is established and the gypsum/iron filings/sand mixture can flow to the trench invert without mix segregation

- advance the permeable reactive wall installation until complete

- haul & dispose of all trench excavated soils (waste) to a designated area within the South landfill

A productivity of ~1,500 sf per day for a 3-foot thick permeable reactive wall can be achieved/maintained using the above installation procedures.

Permeable Reactive Wall Quantities:

From geoprobe results, ref. attached calcs. => 27,000 sf

Using a productivity of ~1,500 sf per day

27,000 sf ÷ 1,500 sf/day = 18 Days, **SAY 20 Days**

PERMEABLE REACTIVE WALL

Crew Assumptions

1. 5 days to grade the ditch & prepare haul road access for concrete trucks, assume 8 hrs. per day

   - 1-dozer, 1-operator, 1-laborer

2. 20 days to install the permeable reactive wall, assume 10 hrs. per day (11 hrs./day for laborers & operators)

   - 1- backhoe, 1-loader, 2-operators, 3-concrete trucks w/ drivers, 1-dump truck w/ driver, 1-labor foreman, 4-laborers

3. 4 days for site cleanup, assume 8 hrs. per day

   - 1-dozer, 1-loader, 2-operators, 1-dump truck w/ driver, 1-laborer

Unit Price Development

Dozer	40 hrs.	x	$48.75/hr.	=	$1,950
Operator	40 hrs.	x	$46.93/hr.	=	$1,877
Labor	40 hrs.	x	$33.18/hr.	=	$1,327
Backhoe	200 hrs.	x	$69.20/hr.	=	$13,840
Loader	200 hrs.	x	$33.25/hr.	=	$6,650
Operator	440 hrs.	x	$46.93/hr.	=	$20,649
Labor Foreman	220 hrs.	x	$34.67/hr.	=	$7,627
Laborer	880 hrs.	x	$33.18/hr.	=	$29,198
				Subtotal	$83,118

PERMEABLE REACTIVE WALL (cont'd.)

Concrete Truck	600 hrs. x	$85.00/hr.	=	$51,000
Dump Truck	200 hrs. x	$36.60/hr.	=	$7,320
Driver	800 hrs. x	$29.84/hr.	=	$23,872
Dozer	32 hrs. x	$48.75/hr.	=	$1,560
Operator	32 hrs. x	$46.93/hr.	=	$1,501
Laborer	32 hrs. x	$29.84/hr.	=	$955
Dump Truck	32 hrs. x	$36.00/hr.	=	$1,171
Driver	32 hrs. x	$29.84/hr.	=	$955
		Subtotal		$88,334
		Subtotal, previous page		$83,118
		Total		$171,452 ÷ 27,000 sf => $6.35 per sf
		SAY		**$6.40 per sf**

PERMEABLE REACTIVE WALL (cont'd.)

Material Quantities/Cost

Sand

27,000 sf x 3-ft. wide = 81,000 cf ÷ 27 cf/cy = 3,000 cy

3,000 cy x 110% = 3,300 cy, Say 3,500 cy

3,500 cy x 1.62 ton/cy = 5,670 ton, **Say 5,700 ton**

5,700 ton – (300 ton + 1,200 ton) = 4,250 ton, **SAY 4,500 ton**

Material Cost: $9.30/ton for mason sand (concrete sand is $8.80/ton) per Nancy Griskowitz on 2/24/00

Iron Filings

5,700 ton x 5% = 285 ton, **SAY 300 ton**

Material Cost: $394/ton, **SAY $400/ton**, ref. Peerless letter dated 4/7/00

Gypsum

5,700 ton x 20% = 1,140 ton, **SAY 1,200 ton**

Material Cost: $0

Delivery Cost: $22/ton, ref. DuPont (Wm. Lacy Gray, Jr.) letter dated 2/11/00

Bio-Slurry

Material Cost: $1.50/sf for a 3-ft.wide trench, ref. Bob Schlinder/Geo-Con telecon memo dated 1/20/00

SLURRY WALL

This estimate is based on the following installation procedure(s) for the slurry wall:

- grade slurry wall area
- initiate trench excavation
- pump a 5% bentonite & water mixture into the trench excavation to stabilize the trench sidewalls
- mix 3% bentonite & common fill outside of the trench
- push the 3% bentonite and common fill mixture into the trench with a dozer after the design invert of the trench has been achieved & verified
- advance the slurry wall installation until complete
- haul & dispose of all trench excavated soils (waste) to a designated area within the South landfill

A productivity of ~1,500 sf per day for a 3-foot thick slurry wall can be achieved/maintained using the above installation procedures.

Slurry Wall Quantities:

Length x Height => PRW area

Wall area x Wall thickness => Wall volume

1,450 lf x 15 ft. => 21,750 sf

21,750 sf x 3 ft.=> 65,250 cf ÷ 27 cf/cy => 2,417 cy, **SAY 2,450 cy**

Using a productivity of ~1,500 sf per day and a wall area of ~21,800 sf, it will take ~ 15 days to install the slurry wall.

21,800 sf ÷ 1,500 sf/day = ~ **15 Days**

SLURRY WALL (cont'd.)

Crew Assumptions

1. 5 days to grade the ditch, assume 8 hrs. per day
   - 1-dozer, 1-operator, 1-labor foreman, 1-laborer

2. 15 days to install the slurry wall, assume 10 hrs. per day (11 hrs./day for laborers & operators)
   - 1- backhoe, 2-dozers, 1-loader, 3-operators, 1-dump truck w/ driver, 1-water truck w/ driver, 1-4" pump, 1-labor foreman, 2-laborers

3. 3 days for site cleanup, assume 8 hrs. per day
   - 1-dozer, 1-loader, 2-operators, 1-dump truck w/ driver, 1-laborer

Unit Price Development

Dozer	40 hrs.	x	$48.75/hr.	=	$1,950
Operator	40 hrs.	x	$46.93/hr.	=	$1,877
Labor Foreman	40 hrs.	x	$34.67/hr.	=	$1,387
Laborer	40 hrs.	x	$33.18/hr.	=	$1,327
Backhoe	150 hrs.	x	$69.20/hr.	=	$10,380
Dozer	300 hrs.	x	$48.75/hr.	=	$14,625
Operator	495 hrs.	x	$46.93/hr.	=	$23,230
Labor Foreman	145 hrs.	x	$34.69/hr.	=	$5,721
Laborer	330 hrs.	x	$33.18/hr.	=	$10,949
Dump Truck	150 hrs.	x	$36.60/hr.	=	$5,490
Driver	165 hrs.	x	$29.84/hr.	=	$4,924
			Subtotal		$81,860

SLURRY WALL (cont'd.)

Pump - 4"	150 hrs.	×	$7.00/hr.	=	$1,050
Dozer	32 hrs.	×	$48.75/hr.	=	$1,560
Loader	32 hrs.	×	$33.25/hr.	=	$1,064
Operator	64 hrs.	×	$46.93/hr.	=	$3,004
Labor	32 hrs.	×	$33.18/hr.	=	$1,064
Dump Truck	32 hrs.	×	$36.60/hr.	=	$1,171
Driver	32 hrs.	×	$28.84/hr.	=	$ 955
Water Truck	120 hrs.	×	$28.57/hr.	=	$3,428
Driver	120 hrs.	×	$29.84/hr.	=	$3,581
			Subtotal		$16,877
			Subtotal, previous page		$81,860
			Total		$98,737 ÷ 21,800 sf => $4.53/sf
			SAY		**$4.60 per sf**

SLURRY WALL (cont'd.)

Material Quantities

The following mixing rates and material costs were obtained from Mike Cary of Geo-Con.

Mix 6 lbs/sf (of wall) of bentonite with water

1,450 lf x 15 ft. = 21,750 sf x 6 lbs/sf = 130,500 lbs. ÷ 2,000 lbs/ton = 65.8 ton, **SAY 66 ton**

Mix 55 #/cy of bentonite with backfill

21,750 sf x 3 ft. = 65,250 cf ÷ 27 cf/cy = 2,420 cy x 55 #/cy = 133,100 lbs. ÷ 2,000 lbs/ton = 66.5 tons, **SAY 67 ton**

Bentonite

Bentonite cost including delivery is $135/ton

66 ton + 67 ton = 133 ton

   SAY   135 ton

Common Fill

Limited displacement by bentonite

Wall volume x 10%

2,450 cy x 110% = 2,695 cy .

   SAY   2,700 cy

Material Cost: $11.25/cy, ref. John Wolfe memo dated 1/24/00

SOUTH LANDFILL CLOSURE COSTS

Case #	Description	Cost per Acre (cap components only)	Cost per Acre (total closure)
Case 1	6" topsoil	$ 3,833	$ 5,788
Case 2	6" topsoil	$ 3,832	
	12" barrier soil	$ 19,994	
	Total Cost	$ **23,826**	$ 35,977
Case 2-1	6" topsoil	$ 3,833	
	12" cover soil	$ 25,985	
	12" barrier soil	$ 19,994	
	Total Cost	$ **49,812**	$ 75,216
Case 3	6" topsoil	$ 3,833	
	bentonite mat	$ 21,344	
	Total Cost	$ **25,177**	$ 38,017
Case 3-1	6" topsoil	$ 3,833	
	12" cover soil	$ 25,985	
	bentonite mat	$ 21,344	
	Total Cost	$ **51,162**	$ 77,255
Case 3a	6" topsoil	$ 3,833	
	drainage net	$ 23,958	
	bentonite mat	$ 21,344	
	Total Cost	$ **49,135**	$ 74,194

SOUTH LANDFILL CLOSURE COSTS (cont'd.)

Case #	Description	Cost per Acre (cap components only)		Cost per Acre (total closure)
Case 3a-1	6" topsoil	$	3,833	
	12" cover soil	$	25,985	
	drainage net	$	23,958	
	bentonite mat	$	21,344	
	Total Cost	**$**	**75,120**	**$ 113,431**
Case 4	4" asphalt	$	30,928	
	8" stone	$	35,719	
	geosynthetic liner	$	16,177	
	bentonite mat	$	21,344	
	Total Cost	**$**	**104,168**	**$ 157,294**
Case 4-1	4" asphalt	$	30,928	
	8" stone	$	35,719	
	24" waste	$	15,633	
	Total Cost	**$**	**82,280**	**$ 124,243**
Case 4a	4" asphalt	$	30,928	
	8" stone	$	35,719	
	drainage net	$	23,958	
	geosynthetic liner	$	16,177	
	bentonite mat	$	21,344	
	Total Cost	**$**	**128,126**	**$ 193,470**
Case 4a-1	4" asphalt	$	30,928	
	8" stone	$	35,719	
	drainage net	$	23,958	
	24" waste	$	15,633	
	Total Cost	**$**	**106,238**	**$ 160,419**

SOUTH LANDFILL CLOSURE COSTS (cont'd.)

Case #	Description	Cost per Acre (cap components only)		Cost per Acre (total closure)
Case 5	6" topsoil	$	3,833	
	12" cover soil	$	25,985	
	geosynthetic liner	$	16,177	
	12" barrier soil	$	19,994	
	Total Cost	**$**	**65,989**	**$ 99,643**
Case 5a	6" topsoil	$	3,833	
	12" cover soil	$	25,985	
	drainage net	$	23,958	
	geosynthetic liner	$	16,177	
	12" barrier soil	$	19,994	
	Total Cost	**$**	**89,947**	**$ 135,820**

PROPOSED CAP COSTS

Material Costs

Topsoil

Unit price taken from DuPont North Landfill estimate dated 3/00

$ 3,833.32 / acre

12" Barrier Soil (low permeable soil)

Material supplied by DuPont at a site 15 miles round trip from work area. Placement cost same as fill cost at the North Landfill

load & transport		$ 7.54/cy
placement		$ 4.84/cy
	cost/cy	$ 12.38/cy

$ 12.38/cy x 1,615 cy/acre = **$ 19,993.70 / acre**

Bentonite Mat (geosynthetic clay liner)

Unit price taken from DuPont North Landfill estimate dated 3/00

bentonite mat $ 0.49/sf

$ 0.49/sf x 43,560 sf/acre = **$ 21,344.4.00 / acre**

4" Asphalt Concrete

Price taken from DuPont North Landfill estimate dated 3/00

3" binder course cost		$ 0.50/sf
1" top course cost		$ 0.21/sf
	cost/sf	$ 0.71/sf

$0.71/sf x 43,560 sf/acre = **$ 30,927.60 / acre**

PROPOSED CAP COSTS (cont'd.)

Material Costs

8" Stone

Unit price taken from DuPont North Landfill estimate dated 3/00

8" stone $ 0.82/sf

$ 0.82/sf x 43,560 sf/acre = **$ 35,719.20 / acre**

Drainage Geonet (geocomposite)

Quote from Chanango Contracting $ 0.55/sf

$ 0.55/sf x 43,560 sf/acre = **$ 23,958.00 / acre**

Geosynthetic Liner

Unit price taken from DuPont North Landfill estimate dated 3/00

geosynthetic liner $ 0.37/sf

$ 0.37/sf x 43,560 sf/acre = **$ 16,117.20 / acre**

12" of Cover Soil

Unit price taken from DuPont North Landfill estimate dated 3/00

$ 16.09/cy x 1,615 cy/acre = **$ 25,985.35 / acre**

PROPOSED CAP COSTS (cont'd.)

Material Costs

24" of Waste

Unit price taken from DuPont North Landfill estimate dated 3/00

placement cost same as placing barrier soil x 2 lifts

barrier soil	$ 16.09/cy
deduct material	$ 11.25/cy
cost/cy	$ 4.84/cy

$ 4.84/cy x 3,230 cy/acre = **$ 15,633.20 / acre**

RIVERBANK PROTECTION

Furnish and place 18 inches of riprap along the South bank of the Christina River from the James Street Bridge to ~ 40 feet upstream from the west end of the proposed slurry wall/permeable reactive wall junction. The riprap will be mixed with 30% by volume, common fill.

MHW	+4.2	Vertical Distance	8.0'
MLW		Horizontal Distance	16.0'
Freeboard	2.0'	Sloped Distance (use 1:2 slope)	18.0'
Total	8.0'		

Install a 3' x 3' keyway at MLW (toe of slope)

Length	1,400 lf
Width	18 lf
Depth	18 inches

Riprap - 18 inches

Volume = 1,400 lf x 18 lf x 1.5 ' + 3' x 3' x 1,400 lf

= 37,800 cf + 12,600 cf

= 50,400 cf

= 1,867 CY

SAY 2,000 cy

Bedding Stone - 6 inches

Volume = 1,400 lf x 18 lf x 0.5 ' + 3' x 0.5' x 1,400 lf

= 12,600 cf + 2,100 cf

= 14,700 cf

= 544 CY

SAY 600 cy

Quantity	Unit	Unit Price*	Total
2,000	cy	$ 49.02	$ 98,040.00

*2000 Means 02300 300 0200

Quantity	Unit	Unit Price*	Total
544	cy	$ 22.25	$ 12,104.00

*2000 Means 02300 130 0100

RIVERBANK PROTECTION (cont'd.)

Common Fill

Volume = 2,000 cy x 30%

= 600 cy

Quantity	Unit	Unit Price**		Total
600	cy	$	11.25	$ 6,750.00

**Ref. URS backup

Total $ 116,894.00

Unit Cost $ 116,894 / 2,000 cy = **$ 58.45 per cy**

ROAD CROSSINGS

T/O   Sawcut 4 locations @ 45 lf/ea = 180 lf

Excavation 2 ea. x 50 lf x 15' wide x 1.65' deep = 2,475 cf / 27 cf/cy = 92 cy

Filter fabric 2 ea. x 50 lf x 15' wide = 1,500 sf / 9 sf/sy = 167 sy

subbase 2 ea. x 50 x 15' wide x .7' deep = 1050 cf / 27 cf/cy = 39 cy

8" reinforced concrete pavement 2 ea. x 50 lf x 15' wide = 1,500 sf / 9 sf/sy = 167 sy

mesh 2 x 50 lf x 15' wide = 1,500 sf x 110% = 1,650 sf / 9 sf/sy = 184 sy

2-1/2" binder 2 ea. x 50 lf x 15' wide = 1,500 sf / 9 sf/sy = 167 sy

1" top same quantity as binder, Use 167 sy

Description	Means 2000	Unit Price		Quantity	Unit	Amount	
Sawcut to 3"	02225-760-0010	$	0.91	180	lf	$	163.80
Added Depth 2"	02225-760-0020	$	0.90	180	lf	$	162.00
Excavation	02315-200-4000	$	7.74	92	cy	$	712.08
Trucking	02320-200-0320	$	2.52	92	cy	$	231.84
Filter Fabric	02720-200-6000	$	0.92	167	sy	$	153.64
Stone Subbase	02720-200-0303	$	7.37	39	cy	$	287.43
8" Concrete	02750-100-0100	$	23.47	167	sy	$	3,919.49
Mesh Reinforcement	02750-100-0600	$	3.59	184	sy	$	660.56
2-1/2" Binder Course	02740-300-0160	$	4.49	167	sy	$	749.83
1" Top Course	02740-300-0300	$	1.88	167	sy	$	313.96
Restoration	allowance	$	500	1	ls	$	500.00
					Total Cost	$	7,854.63

Unit Cost $ 7,854.63 / 2 ea = $ 3,927.32 / ea.

ROAD CROSSINGS (cont'd.)

Detours and Traffic Control

T/O   Excavation for detour 2 ea. x 225 lf x 40' wide x .5' deep = 9,000 cf / 27 = 335 cy
filter fabric 2 ea. x 225 lf x 40' wide x 110% = 19,800 sf / 9 = 2,200 sy
8" stone subbase 2 ea. x 225 lf x 40' wide = 18,000 sf / 9 = 2,000 sy
2 1/2 " binder 2 ea. x 225 lf x 40' wide = 18,000 sf / 9 = 2,000 sy
stripping 2 ea. x 225 lf x 4 stripes = 1,800 lf
temporary barricade allow 40 each
traffic control cones allow 125 each
traffic control signs allow 14 each @ 16 sf/each = 224 sf
post for traffic control signs 2/sign x 14 signs = 28 each
removal of detour 2 ea. x 225 x 40' wide x 1' deep = 18,000 / 27 cf/cy = 670 cy
re-spread topsoil same as excavation 335 cy or 2,000 sy
topsoil & seed 2 ea. x 225 lf x 40' wide = 18,000 sf

Description	Means 2000	Unit Price	Quantity	Unit	Amount
Excavation	02315-200-4000	$ 7.74	335	cy	$ 2,592.90
Filter Fabric	02720-200-6000	$ 0.92	2,200	sy	$ 2,024.00
Stone Subbase	02720-200-0303	$ 7.37	2,000	sy	$ 14,740.00
2-1/2" Binder Course	02740-300-0160	$ 4.49	2,000	sy	$ 8,980.00
Pavement Markings	02766-550-0010	$ 0.20	1,800	lf	$ 360.00
Temporary Barricade	01560-100-0410	$ 305.00	40	ea	$ 12,200.00
Traffic Cones	01560-100-0850	$ 18.15	125	ea	$ 2,268.75
Temp. Traffic Signs	02890-700-2000	$ 18.78	224	sf	$ 4,206.72
Temp. Sign Posts	02890-700-1500	$ 34.61	24	ea	$ 830.64
Removal Excavation	02315-200-4000	$ 7.74	670	cy	$ 5,185.80
Re-spread Topsoil	02920-340-3800	$ 4.44	2,000	sy	$ 8,880.00
				Subtotal	$ 62,268.81

ROAD CROSSINGS (cont'd.)

Detours and Traffic Control

Description	Means 2000	Unit Price	Quantity	Unit	Amount
Seed	02920-510-2200	$ 30.50	18	msf	$ 549.00
Remove Detour	Allowance	$ 1.000	1	ls	$ 1,000.00
				Subtotal	$ 1,549.00
				From Previous Sheet	$ 62,268.81
				Total	$ 63,817.81

Detours   Unit Cost $ 63,817.81 / 2 ea. = $ 31,908.91 / ea.
Crossings   Unit Cost $ 7,854.63 / 2 ea. = $ 3,927.32 / ea.

TOTAL $ 35,026.33 / ea.

CAP TIE-IN TO OLD AIRPORT ROAD

Low Permeable Soil Keyway at Each Side of Old Airport Road

Note: Low permeable soil supplied by DuPont, must be loaded and transported approx. 15 miles

T/O   Excavation 2 ea. x 1,000 lf x 2' wide x 2' deep = 8,000 cf / 27 cf/cy = 300 cy

Allow: 1 cy backhoe, truck, and 1 laborer for 4 days excavate keyway @ 500 lf/day
hilift labor foreman 2 laborers & 1 compactor for 4 days place & compact keyway
hilift 1 laborer & 9 trucks for 3 hr. load & transport soil @ 1,000 cy/day
bridge toll $8.00/load at 12 cy / load 300 cy soil is 25 loads

1 Tolls	25 ea	$	8.00	$ 200.00
1 Operator	32 hr	$	46.93	$ 1,501.76
1 Driver	32 hr	$	29.84	$ 954.88
1 Laborer	32 hr	$	33.18	$ 1,061.76
1 Operator	32 hr	$	46.93	$ 1,501.76
1 Labor Forem	32 hr	$	34.67	$ 1,109.44
2 Laborer	32 hr	$	33.18	$ 2,123.52
1 Operator	3 hr	$	46.93	$ 140.79
1 Laborer	3 hr	$	33.18	$ 99.54
9 Driver	3 hr	$	29.84	$ 805.68
1 1 cy Backho	32 hr	$	52.93	$ 1,693.76
1 Hilift	32 hr	$	38.17	$ 1,221.44
1 Compactor	32 hr	$	6.79	$ 217.28
1 Hilift	32 hr	$	38.17	$ 1,221.44
		Subtotal		$ 13,853.05

CAP TIE-IN TO OLD AIRPORT ROAD (cont'd.)

1 Truck	32 hr	$	44.66	$	1,429.12
9 Truck	3 hr	$	44.66	$	1,205.82
		Subtotal		$	2,634.94
		From Previous Sheet		$	13,853.05
		Total Cost		$	16,487.99

Unit Cost $ 16,487.99 / 300 cy = **$ 54.96 / cy**

GENERAL CONDITIONS

Project Schedule

1) Mobilization — 5 days
2) Clear & Grub — 6 days
3) Permeable Wall — 20 days
4) Slurry Wall — 15 days
5) Site Grading — 35 days
6) Cap @ 4 days/acre — 60 days
7) Demobilization — 5 days

146 days ÷ 5 days/wk. = ~ 30 weeks

2000 Means

Office Trailer Means	015-904-0500	8 months x $315/mo.	=	$2,520
Telephone	010-034-0140	8 months x $235/mo.	=	$1,880
Light & Heat	010-034-0160	8 months x $88/mo.	=	$704
Office Supplies	010-034-0120	8 months x $85/mo.	=	$680
Office Equipment	010-034-0100	8 months x $133/mo.	=	$1,064
Port-a-John	016-420-6450	8 months x 4 ea. x $165/mo.	=	$5,280
Superintendent	010-036-0260	30 wks. x $1,245/wk. x 135%	=	$50,423
Project Manager	010-036-0200	30 wks. x $1,320/wk. x 135%	=	$53,460
			Subtotal	$116,011

GENERAL CONDITIONS (cont'd.)

Survey	013-306-1200	20 days x $575/day x 135%	=	$15,525
Small Tools	010-082-0100	$4,800,660 x 0.5%	=	$24,003
Equipment & Mobilization	Geo-Con	Lump Sum	=	$50,000
Handtools & Misc. Matl., moves @ 3 per wk.	022-274-1150	78 ea. x $100/ea.	=	$7,800
Insurance	010-040-0450	$4,800,660 x 0.5%	=	$24,003
Construction Photos 10/mo	013-803-0200	60 ea x $190/ea.	=	$11,400
			Subtotal	$132,731
		Subtotal, previous page		$116,011
			Total	$248,742
			SAY	**$250,000**

DUPONT

DuPont Advanced Fibers Systems

CC: John Wilkens
Leslie Crocker – ISG Corp.

John C. Wokasien
Contruction Manager
URS Greiner Woodward Clyde
282 Delaware Avenue
Buffalo, NY 14202-1805

Dear John,

DuPont Kevlar® agrees to provide the Newport South Landfill up to 200 tons of Gypsum at no charge F.O.B. our James River plant in Richmond, Virginia. Freight will be billed to your project at ~$20-22/ton.

Please provide 30 days lead time when ordering. I understand from John Wilkens that the material will not be needed until 2001.

Very truly yours,

William Lacy Gray, Jr.
Contracted Manufacturing Manager
Advanced Fibers Systems
(804) 383-4459

WLG/jwa
ISGWokasien letter.doc
Kevlar® is a DuPont registered trademark

AR324544

DUPONT

DuPont Advanced Fibers Systems

FACSIMILE TRANSMITTAL COVER SHEET

TO: _____ John C. Wekasien_____

LOCATION: _____

PHONE _____ FAX NO. 716-856-2545

DATE: 2-11-00

FAX: 804 - 383-3327

FROM: _____ CHARLIE SIMMONS (804) 383-4086

_____X_____ LACY GRAY (804) 383-4459

_____ JANE AREHART (804) 383-2562

NUMBER OF PAGES (INCLUDING COVER SHEET): 2

IF TRANSMITTAL HAS NOT BEEN COMPLETED, CALL 804-383-2562

NOTES: See Letter attached.

AR324545

FACSIMILE TRANSMITTAL SHEET

To: John Wokasien
Company: URS Corp.
Phone: 716-856-5636
FAX: 716-856-2545
Total # of sheets faxed: 9

From: John H. Wolfe
Phone: 302-993-0490
FAX: 302-994-3481

Urgent ( ) For review ( ) Reply ( )Information Requested (X)

Message:

John

   Attached are the rate sheets you requested.

The price for Common Fill from Contractors Materials LLC is:
$6.80 per Ton delivered, @ 1.5 ton per Cubic Yard.

$$Allow \ 1.65T/cy \ \therefore \ 6^{80} \times 1.65 = 11^{25}/cy$$

WOLFIE

Laborers Local No. 199

Management Unit	Allied Division, DCA
Jurisdiction	New Castle County, Delaware
Term of Agreement	7 June 99 thru 30 April 2002

Wages & Contributions
(hourly)

	6/7/99	5/1/2000	5/1/2001
Schedule A	$15.84	$.80	$.75
Schedule B	16.09	Total	Total
Schedule C	16.34	Economic	Economic
Schedule D	16.84	Increase	Increase
Schedule E	17.09		
Schedule F	19.09		
Health & Welfare	3.70		
Pension	1.65		
Training & Educ. Fund	.46		
Annuity	2.00		
Industry Advancement	0.8%		

15⁹² *245⁸* *Foreman 25⁸*

`This percentage is multiplied by the
total of wages and fringe contributions
paid.

*Pay entire day at highest rate worked
during day.

Deductions	Union dues - $.34 per hour worked. Effective 5/1/93 - Laborers Political League - $.02 per hour worked.
Premium Pay	If working on stacks, silos, towers, etc. over 50 feet pay $.25 over base wage for each additional 25 feet.
Foremen	1 if 8 thru 19 employees on job, then 1 for every 19 employees. Pay $1.00 per hour over highest paid employee supervised. Non-working.
General Foremen	Pay $1.00 per hour over highest paid employee supervised.
Holidays	New Year's, Memorial Day, July 4, Labor Day, Thanksgiving, Christmas, General Election Day if declared by Building & Construction Trades Council. Holidays on Saturday or Sunday celebrate Friday and Monday, respectively.
Overtime & Holiday Pay	The first two hours of overtime worked Monday thru Friday and the first ten hours worked on Saturday will be paid at 1 1/2x wages, 1x contributions and 1x dues. All Sundays, holidays and over ten hours will be paid at 2x wages, 1x contributions and 1x dues. General Election Day, if worked, at straight time rates.
Straight Time Hours	8 hours between 8:00 a.m. and 4:30 p.m., Monday thru Friday.
Shifts & Differential	If 2 shifts of over 8 hours each - equal

CEA$199 6/99

	pay and duration. Otherwise: 1st - midnight to 7:30 a.m. for 8 hours pay, 2nd - straight time hours and pay, 3rd - 4:30 p.m. to midnight for 8 hours pay.
Pay & Pay Day	By check no later than quitting time Friday. Withhold 5 days. Make arrangements as to how and where checks to be cashed.
Reporting Time	No show up time if work not started due to weather. If work starts and is stopped, pay greater of 2 hours or actual time, unless stopped due to weather, then pay actual time only. If works 4 hours pay for 8 hours. If call for men in a.m. of day worked, pay 8 hours. If call for men to work in p.m. pay 4 hours.
Meal Periods	1/2 hour (unpaid) each shift. On continuous overtime: 1/2 hour (paid) after 2 hours work and after each 4 hours worked thereafter, provided work continues after meal period. On non-scheduled overtime allow reasonable arrangement to get food.
Coffee Break	15 minutes between 9:30 a.m. and 11:00 a.m. at work station.
Transportation	No payments provided job in Local's jurisdiction.
Lay Off/Discharge	If employed for more than 2 days on job, pay and allow 1/2 hour to pack tools.

Work Classifications By Schedule

Schedule A	Laborers, general and construction Dumpmen Fire Watchmen Flagmen Salamanders Truck Spotters
Schedule B	Caulkers; operators of pneumatic and electric tools; vibrating machines; concrete saws and pumps (which shall include the hook-up of hose and/or pipe); pot tenders; and sewer pipe layers Demolition (where walls are required to be ridden down by hand tools) Driller (except Core, Diamond, or Multiple Wagon) Fork Lift Laborer Gunite material and rebound workers Mason and plaster tenders, and cement workers Mobile buggy operators Operators of power saws (portable)

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Power and Sewing Machines
Scaffold builders
Shoring
Signal men and hookup men, including when
working with digging and grading equip.
Stripping of flat arch and form work, and
cleaning and oiling thereof
Tool room attendant

Schedule C   Burners and Welders
Caisson Workers, top men (when excavations
for caissons are dug eight feet or more
below the natural grade level adjacent
to the starting point of the caisson
hole, the rate shall apply at the ground
level)
Concrete Specialist
Driller (Core, Diamond, or Multiple Wagon)
Gunite industrial fume stack, nozzle, and
rod workers
Sandblaster (nozzlemen)
Tunnelling
Underpinning Excavation (when an under-
pinning excavation is dug eight feet or
more below the natural grade, or when an
excavation for a pier hole of five feet
square or less and eight feet or more
deep is dug, the rate shall apply only
when a depth of eight feet is reached)
Working under compressed air

Schedule D   Caisson workers, bottom men (see qualifi-
cations for top men in Schedule C above)

Schedule E   Blasters
Laborers engaged in unloading, placing,
and assisting in the installation of well
point systems or deep well sytems as long
as needed on the job for such work

Schedule F   Asbestos and/or Toxic or Hazardous Waste
Workers (tasks related to asbestos and/
or toxic waste removal - certified and
licensed workers only)
Lead Abatement Worker

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AR324549

Operating Engineers Local No. 542
Note: All information for State of Delaware Building & Heavy Work
        Only.

Management Unit:	Allied Division, DCA		
Jurisdiction	State of Delaware		
Term of Agreement	1 May 99 thru 30 April 2002		
Hourly Base Wages	5/1/99	5/1/00	5/1/01
Wage Group I:			
Hourly Base Wage	$22.45	$22.69	$22.94
Health & Welfare	4.29	4.53	4.67
Surcharge	.70	.90	1.00
Pension	2.36	2.38	2.41
Apprentice	.22	.23	.23
SUB	.45	.45	.46
Annuity	3.50	4.00	4.25
Wage Group II:			
Hourly Base Wage	$22.25	$22.36	$22.62
Health & Welfare	4.24	4.48	4.62
Surcharge	.70	.90	1.00
Pension	2.33	2.36	2.38
Apprentice	.22	.22	.22
SUB	.44	.45	.45
Annuity	3.50	4.00	4.25
Wage Group III:			
Hourly Base Wage	$20.19	$20.35	$20.56
Health & Welfare	3.93	4.16	4.29
Surcharge	.70	.90	1.00
Pension	2.12	2.14	2.16
Apprentice	.20	.21	.21
SUB	.40	.40	.41
Annuity	3.50	4.00	4.25
Wage Group IV:			
Hourly Base Wage	$19.86	$19.99	$20.20
Health & Welfare	3.87	4.10	4.23
Surcharge	.70	.90	1.00
Pension	2.09	2.10	2.13
Apprentice	.20	.20	.20
SUB	.40	.40	.40
Annuity	3.40	4.00	4.25
Wage Group V:			
Hourly Base Wage	$18.01	$18.12	$18.24
Health & Welfare	3.58	3.80	3.93
Surcharge	.70	.90	1.00
Pension	1.90	1.90	1.92
Apprentice	.18	.18	.18
SUB	.36	.36	.36
Annuity	3.50	4.00	4.25

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Wage Group VI:

Hourly Base Wage	$17.49	$17.57	$17.72
Health & Welfare	3.59	3.71	3.84
Surcharge	.70	.90	1.00
Pension	1.84	1.84	1.86
Apprentice	.17	.18	.18
SUB	.35	.35	.35
Annuity	3.50	4.00	4.25

Toxic/Hazardous Waste Removal Rate:20% added to all classifications

Machines with booms, jibs, masts, and leads: 100 feet and over -
   $.50 per hour additional will be paid for each increment of
   25 feet over 100 feet.

Apprentice Rates

Probation to 1st 6 months	50%
2nd six (6) months	55%
3rd six (6) months	60%
4th six (6) months	65%
5th six (6) months	70%
6th six (6) months	75%
7th six (6) months	80%
8th six (6) months	85%

Deductions	Union dues - 3.7% of wages. Political Action Fund - 0.2% of wages.
Lead Engineer	1 for 7 or more engineers. Rate - $1.50 per hour over rate on weekly basis of highest paid engineer on same job.
Ass't Lead Engineer	1 for over 25 employees and for each multiple of 25. Rate - $.90 per hour above rate on weekly basis of highest paid engineer on same job.
Holidays (Paid)	New Year's, Memorial Day, July 4, Labor Day, Thanksgiving, Day after Thanksgiving Christmas or day so celebrated except when falls on Sunday and provided employee works scheduled work day before and after the holiday.
Overtime & Holiday Pay	The first two hours of daily overtime, Monday thru Friday and the first eight hours on Saturday shall be paid at 1 1/2x wages plus contribution and deduction percentages noted above. Sundays, holidays and hours in excess of ten are to be paid at 2x wages plus contribution and deduction percentages as noted above.
Straight Time Hours	8 hours between 8:00 a.m. and 4:30 p.m., Monday thru Friday. Employer may vary starting time by 1 hour.
Shifts & Differential	Time of starting 1st shift at employer's option. No shift in excess of 8 hours

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work. Discuss shift duration with Local.
Pay straight time to shift closest to
straight time hours and straight time plus
5% to other shifts.

Pay & Pay Day

By cash or check, at Local's option, by
quitting time on regular pay day.
Withhold 3 days pay.

Weekly Guarantee

If employer's job continues for over 5
days, guarantee 40 hours per week at
weekly rate for the days the job lasts.

Reporting Time

If on weekly guarantee see above. On daily
basis, i.e. less than 5 days on job:
4 hours show-up and if started to work,
pay 8 hours. On Sundays and holidays
6 hours show-up, 8 hours if start work,
pay @ overtime rate. If not started to
work within 1 hour, dismiss for the day.

Meal Periods

1/2 hour, unpaid. On single shift work,
at noon. On multiple shift work between
3rd and 5th hours.

Lay Off/Discharge

Pay in full upon termination.

Work Classifications By Group

Wage Group I

Handling steel and stone in connection
    with erection
Cranes doing hook work
Any machines handling machinery
Cable spinning machine
Helicopters
Concrete Pumps
Machines similar to the above including
    remote control equipment.

Wage Group II

All types of cranes
All types of backhoes
Cableways
Conveyor Loader
Drag Lines
Keystones
All types of shovels
Derricks
Trench Shovels
Trenching machines
Pippin type backhoes
Hoist with two towers
All Pavers (Concrete and Blacktop)
All types overhead cranes
Building Hoists - double drum
    (unless used as single drum)
Milling Machine
Mucking machines in tunnel

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Gradalls
Front-end loaders
Boat Captain
Tandem Scrapers
Tower type crane operation, erecting,
    dismantling, jumping, or jacking
Drills self-contained (Drillmaster type)
Chipper with Boom
Tree Spade
Concrete breaking machines (Guillotine
        type and remote type
Fork Lift (20 feet and over)
Motor Patrols (Fine Grade)
Batch Plant with mixer
Scrapers & Tournapulls
Rollers (High Grade Finishing)
Mechanic Welder
Spreaders
Bundle Puller Extractor
Hydro Axle
Side Boom
Bob Cat Type (All attachments)
Vermeer Saw
Directional Boring Machine
Bulldozers & Tractors
Machines similar to the above

Wage Group III

Conveyors (Except Building Conveyors)
Building Hoists (Single Drum)
Asphalt Plant engineer
High or low pressure boilers
Well Drillers
Fork Lift trucks of all types
Ditch witch type trencher
Motor Patrol
Concrete breaking machines
Rollers
Fine Grade Machines
Elevator Operator (new construction)
Stump grinder
Machines similar to the above

Wage Group IV

Seaman pulverizing mixer
Tireman on Power Equipment
Maintenance Engineer (Power Boat)
Farm Tractors
Form Line Graders
Road Finishing Machines
Power Boom
Seed Spreader
Grease Truck
Machines similar to the above

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Wage Group V   Conveyors (Building)
                                      Welding machines
                                      Heaters
                                      Wellpoints
                                      Compressors
                                      Pumps
                                      Miscellaneous Equipment Operator
                                      Elevator Operators (renovations)
                                      House Car
                                      Machines similar to the above

Wage Group VI   Fireman
                                      Oilers and Deck Hands (Personnel
                                       Boats)
                                      Grease Truck Helper

Wage Group VII (A)   (See Wage Group I)
Toxic/Hazardous
Waste Removal

Wage Group VII (B)   (See Wage Group II)
Toxic/Hazardous
Waste Removal

"Nancy J Griskowitz" <Nancy.J.Griskowitz@USA.dupont.com> on 02/03/2000 12:30:08 PM

To: "Brandt Butler" <Brandt.Butler@USA.dupont.com>, John Wokasien/Buffalo@URSGreiner
cc:

Subject: Re: SLF Drawing

The area bounded by the limits of waste is approximately 15.9 acres as
calculated by AutoCAD.

To: "Jim L Aker" <Jim.L.Aker@USA.dupont.com>, "Edward M Andrechak"
        <Edward.M.Andrechak@USA.dupont.com>, "Craig L Bartlett" <Craig.L.Bartlett@USA.dupont.com>,
        "Matthew P Brill" <Matthew.P.Brill@USA.dupont.com>, "Brandt Butler" <Brandt.Butler@USA.dupont.com>,
        "Nancy J Griskowitz" <Nancy.J.Griskowitz@USA.dupont.com>, "John L Guglielmetti"
        <John.L.Guglielmetti@USA.dupont.com>, "Richard H Jensen" <Richard.H.Jensen@USA.dupont.com>,
        "William R Kahl" <William.R.Kahl@USA.dupont.com>, "Richard C Landis"
        <Richard.C.Landis-1@USA.dupont.com>, "Edward J Lutz" <Edward.J.Lutz@USA.dupont.com>, Tom
        Nowocien/Buffalo@URSGreiner, "William B Pew" <William.B.Pew@USA.dupont.com>, "Noel C Scrivner"
        <Noel.C.Scrivner@USA.dupont.com>, "Stephen H Shoemaker"
        <STEPHEN.H.SHOEMAKER@USA.dupont.com>, "Marjorie E Vetter"
        <Marjorie.E.Vetter@USA.dupont.com>, "John E Vidumsky" <John.E.Vidumsky@USA.dupont.com>, "John
        A Wilkens" <John.A.Wilkens@USA.dupont.com>, "John H Wolfe" <John.H.Wolfe@USA.dupont.com>,
        John Wokasien/Buffalo@URSGreiner, robert@kiber.com, george@kiber.com

cc:

Subject: South Landfill Team Update - Current Tasks and Notes from February 2nd Meeting

---

Team,

Please note our new meeting schedule.

Upcoming Meetings 8:30am - 10:30am

        February 14   27-2374 - Team - Review Kiber, Xsta Results, Finalize
                        cost estimate assumptions, set date for CRG Peer Review
                        (302)709-8000 + 2653#
                        AGENDA For February 14
                            XSta Testing
                            Kiber Testing
                            Cost Estimates
                            EPA Feedback
                            Schedule and scope for Peer Review
                            Schedule and scope for EPA Meeting
                            Loose ends not covered
                            Path Forward & Schedule

        February ??   CRG Peer Review
        Early March   EPA-DuPont meeting to discuss path forward
        March 8   Review status. Chose technology and design path. Scope
                    next phase.

    (Attached (in Adobe Reader) is a copy of the current project schedule -
please review it, especially your dates - before our next meeting - I plan
                    to use it to monitor progress.

                    ((See attached file: npt309.pdf))

Current Tasks
    Wilkens
            Gathering analytical data, proposing permeable wall composition
            Scope lab scale flow-through-test with target wall composition
            Issue note with non-delivery months for James River gypsum

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Kiber
        Issue draft report
        Complete gypsum/fill permeability tests and issue draft results
Kahl/Griskowitz
        Scope geo-probe type testing for groundwater outside of south
        landfill - develop requisite plans
        Scope in-situ treatability testing for PRW
        Calculate waste volume and wall depths based on topo maps
Butler
        Send out gw data package to team
        Draft EPA submittal for presentation of new data and path
        forward, emphasize low zinc release
Wokasien
        Finalize cost-estimates with proposed wall composition
Nowocien
        Develop shipping cost for lime from Montague, Michigan

Meeting Notes - 2/2/2000
    Field Activities
        Issued drawings with new data
        Developing more info on geo-probe testing
            field scope - determine depth to marsh, gw composition
            pif
            PSA/HASP/WMP
            survey
            schedule
        Develop scope while preparing for EPA presentation
    Kiber
        Completed verification testing - portland (3%), lime (3%), or
        gypsum (5%) are effective - now its a matter of cost
        Set up permeability tests w/gypsum and common fill - expect
        results 2/9/2000
        Draft report to issue 2/11/2000
    Wilkens
        Tests complete for screening dosages - awaiting analytical
        results
        Propose wall composition for ~100 year wall life (if
        practical)
        Next phase - use proposed wall composition/ratio and retreat
        groundwater
        (Following the meeting, J. Aker requested a flow through test
        for next phase, rather than the shaker tests)
        GW flow analysis shows 0.8 ppm zinc at 200 ml/min ->86 gm/day
        (a handful of Cold-Ease tablets)
        Likely some synergistic reaction with Ba-rich and Zn-rich
        water - future study emphasis should shift to gw outside the
        wall
        Suggest review of results with EPA and present geoprobe-type
        sampling plan (w/decision tree) to see if low zinc outside the
        landfill would eliminate need for treatment..
        Discussed need for sampling groundwater outside of landfill -
        Kahl will develop a scope for geo-probe-type testing - data
        needed - depth to top of marsh deposit and gw sample (~20
        locations outside landfill on east and south sides
    Wokasien - Cost-Estimates
        Upgraded cost-estimates were presented
        Looking at cost comparison of various barium agents (Portland
        Cement - 3%, Hydrated Lime - 3%, and Gypsum - 5%) - will put
        lowest cost in estimate

Must confirm shipping costs
Recalculating volume and depth of wall based on topo maps of
ground surface and top-of-march surface

- npt309.pdf

R01100-050   General Contractor's Overhead

The table below shows a contractor's overhead as a percentage of direct cost in two ways. The figures on the right are for the overhead, markup based on both material and labor. The figures on the left are based on the entire overhead applied only to the labor. This figure would be used if the owner supplied the materials or if a contract is for labor only. Note: Some of these markups are included in the labor rates shown on Reference Table R01100-070.

| | % of Direct Costs | |
Items of General Contractor's Indirect Costs	As a Markup of Labor Only	As a Markup of Both Material and Labor
Field Supervision	6.0%	2.9%
Main Office Expense (see details below)	16.2	7.7
Tools and Minor Equipment	1.0	0.5
Workers' Compensation & Employers' Liability. See R01100-060	18.1	8.6
Field Office, Sheds, Photos, Etc.	1.5	0.7
Performance and Payment Bond, 0.7% to 1.5%. See R01100-080	2.3	1.1
Unemployment Tax See R01100-100 (Combined Federal and State)	7.0	3.3
Social Security and Medicare, See R01100-100	7.7	3.7
Sales Tax — add if applicable 42/80 x % as markup of total direct costs including both material and labor. See R01100-090		
Sub Total	59.8%	28.5%
*Builder's Risk Insurance ranges from .141% to .586%. See R01100-040	0.6	0.3
*Public Liability Insurance	3.2	1.5
Grand Total	63.6%	30.3%

*Paid by Owner or Contractor

Main Office Expense

A General Contractor's main office expense consists of many items not detailed in the front portion of the book. The percentage of main office expense declines with increased annual volume of the contractor. Typical main office expense ranges from 2% to 20% with the median about 7.2% of total volume. This equals about 7.7% of direct costs. The following are approximate percentages of total overhead for different items usually included in a General Contractor's main office overhead. With different accounting procedures, these percentages may vary.

Item	Typical Range		Average
Managers', clerical and estimators' salaries	40% to	55%	48%
Profit sharing, pension and bonus plans	2 to	20	12
Insurance	5 to	8	6
Estimating and project management (not including salaries)	5 to	9	7
Legal, accounting and data processing	0.5 to	5	3
Automobile and light truck expense	2 to	8	5
Depreciation of overhead capital expenditures	2 to	6	4
Maintenance of office equipment	0.1 to	1.5	1
Office rental	3 to	5	4
Utilities including phone and light	1 to	3	2
Miscellaneous	5 to	15	8
Total			100%

URS Greiner

MEMO OF TELECON

JOB NO.: 05000 3572900

JOB TITLE: Du Dont

PERSON CALLING: Dick Davison

REPRESENTING:

TELEPHONE #:

SUBJECT:

DATE: 1/20/00

FILE UNDER:

PERSON CALLED: Mike Cary

REPRESENTING: Geo Con

SUMMARY OF CONVERSATION:

Mix Bentonite with water aprox 5% of water
This is 6#/SF
Load Spoil to truck & Dispose

Add Aprox 3 to 4% Dry bentonite to Borrow w/Dozer
And push into Ditch. This is 55#/cy

Hoe - 1 to 2 Dozer - LF 2 LBR   Use 2000 SF/Day
1500 to 2000 SF/D
wet aria
Cost should be $6- to $8-/SF This is a SMALL
Shollow Project

cc:

AR324560

URS Greiner

282 Delaware Avenue
Buffalo, New York 14202
(716) 856-5636

MEMO OF TELECON

JOB NO.: 05000 357 29 00

DATE: 1/20/00

JOB TITLE: DuPont

FILE UNDER: _____

PERSON CALLING: Dick Davison

PERSON CALLED: Bob Schliwow

REPRESENTING: U.R.S.G w.C

REPRESENTING: Geo Con

TELEPHONE #: 1-813-626-0751

SUBJECT: Permeable Retaining Wall

SUMMARY OF CONVERSATION: Bob Advised that Bio Slurry would cost Aprox 1⁵⁰/SF of 3' 7" wide trench plus the cost of mixing. The Gyp & Iron filling mix should be started with a Trimi and After a Leading edge of backfill is in Ditch w/a sloped end the matl may be added at high end of backfill and allowed to Roll to Bottom of Ditch. This material will not Seperate if placed in this manner

cc:

AR324561

URS Greiner

MEMO OF TELECON

JOB NO.: _C6000 3572900_   DATE: _1/19/00_

JOB TITLE: _Dupont_   FILE UNDER: _____

PERSON CALLING: _Dick Davison_   PERSON CALLED: _Mike Cary_

REPRESENTING: _U.R.S._   REPRESENTING: _Geo Con_

TELEPHONE #: _1-412-856-7700_

SUBJECT: _Slurry Wall - Permeable Retentive Wall_

SUMMARY OF CONVERSATION:

To build wall mix Bio Slurry & pump into Excavation while Excavating. Place mixture of Gypsum 10% - Iron Fillings 1% & common fill 89% into Excavation thru trimi to bottom of Excavation - Bio Slurry will float out of Excavation. Allow for Exc overrun

    Mix Fill - Gyp - & Fill in concrete truck

    Bio Slurry & wall construction aprox 2000 SF/DAY with hoe - ope - pump - mixer. 5 man crew
thlift - 2 conc trk - & be mix & wall mate.

Need Hoppers to change concrete trucks

This is a patented procedure and there is a royalty of Aprox. 15% to a Canadian company for its use

Aprox cost Permeable Reactive Wall 15$/SF
    "   "   Slurry wall $4 to $6 /SF

CC:

AR324562

PEERLESS™

April 7, 2000

John Wokasien   FAX: 716-856-2545
URS Consultants
282 Delaware
Buffalo, NY 14202

Dear John:

Thank you for the opportunity to quote on your requirements for Cast Iron Aggregate at the
DuPont - Newport, DE site.

       Cast Iron Aggregate Size 8/50-------------------------$330/NT

       Plus packaging in 3000# bulk bags, palletized-----$ 14/NT ($21/per bag)

Prices are FOB Detroit, MI. Terms – Net 30 Days.

I found the following freight rate Detroit, MI to Newport, DE:

       Flatbed Truck---$1125 = $50/NT (based on 22.5 tons)

Should you require us to prepay and add the freight, please add 15% to the above freight price.

We appreciate the opportunity to give you this quote. As you are aware the cost of producing and
transporting iron is market driven and therefore can change over time; please contact us for a final
quote at the time the iron is required for the project.

Very truly yours,

Paul W. Tousley
President & CEO

Noreen P. Warrens
Cast Iron Sales

PWT/npw

Peerless Metal Powders & Abrasive   124 South Military • Detroit, Michigan 48209
AR324563(313) 841-5400   Fax (313) 841-0240

LESS ™

Peerless Metal Powders & Abrasive

124 South Military   Detroit, Michigan 48209
313 841-5400   Fax 313 841-0240

FAX TRANSMITTAL

We are transmitting a total of __2__ pages including this cover sheet. Please contact sender if you do not receive the entire transmission.

PLEASE DELIVER THE FOLLOWING PAGES TO:

NAME _John Wokasien_

COMPANY _URS Consultants_

FAX # _716·856·2545_   PHONE # _____

FROM _Joreen Waire_ DATE _4-10-00_

MESSAGE:

_____

_____

_____

_____

_____

_____

Peerless Metal Powders & Abrasive

124 South Military • Detroit, Michigan 48209
(313) 841-5400   Fax (313) 841-0240

AR324564

To: John Wokasien

Location	Depth to Marsh deposit
GW-8	15
GW-9	5
GW-10	5.5
GW-11	9
GW-12	5
GW-13	5
GW-14	5
GW-15	5
CW-16	2
GW-17	5
GW-19	10
GW-20C	6
GW-21	6
GW-22A	16
GW-22B	15
GW-22C	8

Post-It® Fax Note 7671

To: J. Wokasien
Co./Dept:
Phone #:
Fax # 716-856-2545

Date 3/27/0. # of pages ▶ 2
From: Rusty Kahl
Co. WCD - Wilmington
Phone 302 892-0618
Fax # 302-892-7643

these are the only locations ~~in~~ in which I ~~have~~ found the marsh deposit.

GW-1 ~ 11 ft
GW-3 ~ 15 ft
GW-4 ~ 12.5 ft
GW-6 ~ 22 ft
GW-7 ~ 19 ft

these are all estimates based on boring logs from a 1993 DelDOT report.

Please call 302-892-0618 if you have questions.

— Rusty

LEGEND

■ TEST PIT

⚲ ABANDONED WELL

⊕ CURRENT WELL

◯ 1997 WELLS EXCEEDING PERFORMANCE STANDARDS

◯ 1998 WELLS EXCEEDING PERFORMANCE STANDARDS

◯ 1999 WELLS EXCEEDING PERFORMANCE STANDARDS

CHRISTINA

RIVER

SCALE: 1" = 200'

RT. 141

SOUTH LANDFILL
WELLS AND TEST PITS
NEWPORT SUPERFUND SITE
NEWPORT, DELAWARE
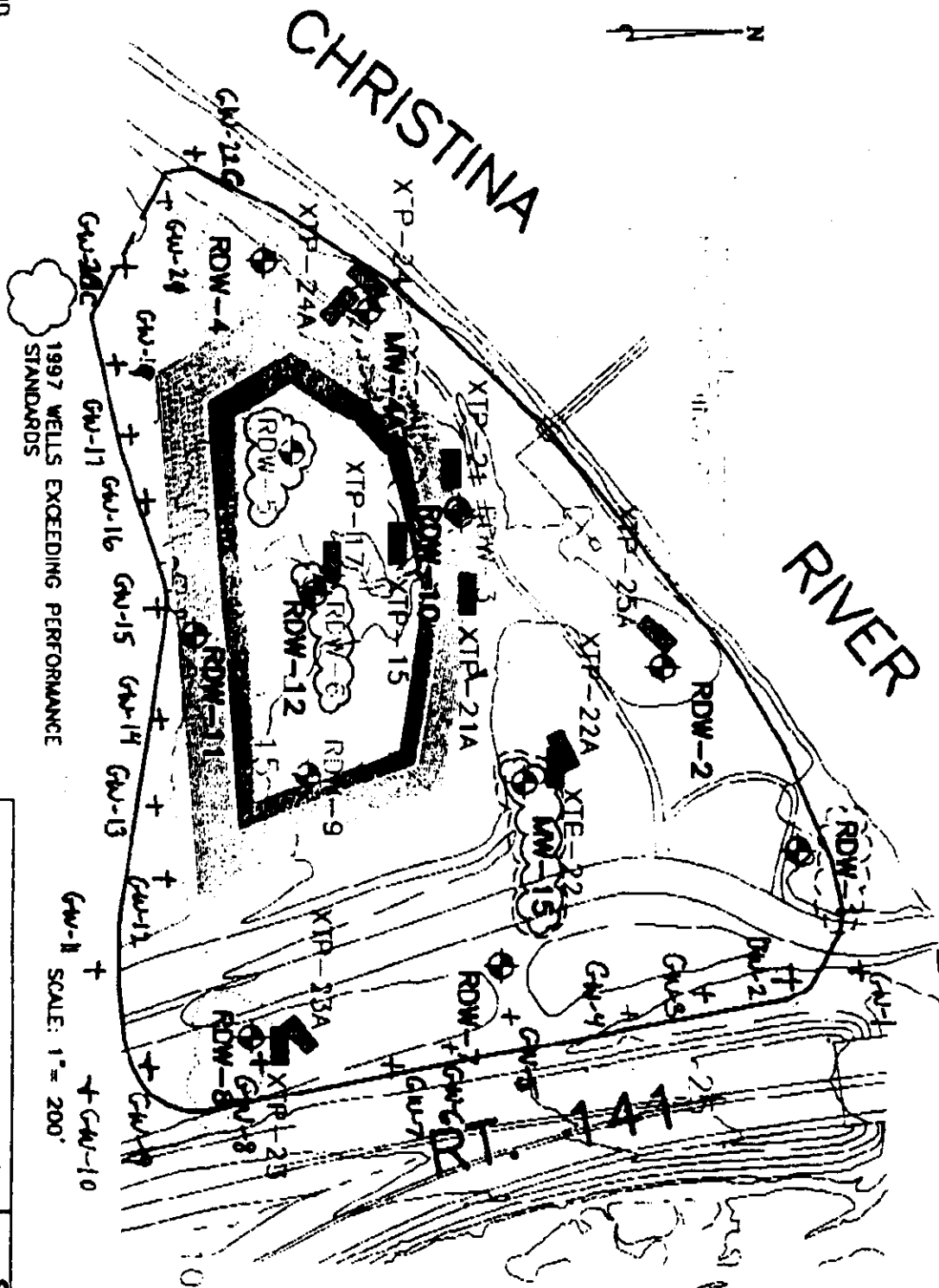
Corporate Remediation Group
An Alliance between
DuPont and The B·C Diamond Group

Barley Mill Plaza Building 27
Wilmington, Delaware 19880-0027

AR324566

URS Greiner Woodward Clyde

Job DUPONT - SOUTH LANDFILL   Project No. 0500035735.00

Description REMEDY ESTIMATE   Computed by TAO

QUANTITIES   Checked by RW

Page ____ of ____

Sheet 1 of 1

Date 3/29/00

Date 3/30/00

Reference

PERMEABLE REACTIVE WALL VOLUME

- BASED ON BORING LOGS FROM A 1993 REPORT (GW-1 thru GW-7) AND the GEOPROBE RESULTS 2000 (GW-8 thru GW-22c) FROM WCD, the FOLLOWING VOLUME WAS QUANTIFIED:
- DIMENSIONS OF WALL:

  WIDTH = 3FT

  DEPTH · VARIES, MUST "KEY" INTO MARSH DEPOSIT BY 2FT

  LENGTH = BASED ON SITE PLAN (NOT ATTACHED)

$$\left[\left(\left(\underset{\substack{\text{DEPTH} \\ \text{(TYP)}}}{8FT} \times \underset{\substack{\text{LENGTH} \\ \text{(TYP)}}}{200FT}\right) + (12FT \times 125FT) + (7FT \times 850FT) + (17FT \times 270FT) \right.\right.$$
$$+ (21FT \times 135FT) + (24FT \times 140FT) + (15FT \times 145FT)$$
$$\left.\left. + (17FT \times 150FT) + (14FT \times 135FT)\right) \times \underset{\text{WIDTH}}{3}\right] / 27$$

$$\hat{=} 2940 cy$$

SAY   3000 cy

WALL FACE = 9SF/cy OR 27,000 SF

To: John Wokasien
From: Marek Ostrowski
Ref: DuPont South Landfill
        Infiltration estimates

As you requested, I performed infiltration estimates for the types of cap considered for the DuPont South Landfill facility. The caps are:

Case 1:   6" of topsoil, vegetated

Case 2:   6" of topsoil, 12" of barrier soil, vegetated

Case 2-1:   6" of topsoil, 12" of fill, 12" of barrier soil, vegetated

Case 3:   6" of topsoil, bentonite mat, vegetated

Case 3-1:   6" of topsoil, 12" of fill, bentonite mat, vegetated

Case 3a: 6" of topsoil, drainage net, bentonite mat, vegetated

Case 3a-1:   6" of topsoil, 12" of fill, drainage net, bentonite mat, vegetated

Case 4:   4" of asphalt cap, 8" of stone, synthetic liner, bentonite mat

Case 4-1:   4" of asphalt cap, 8" of stone

Case 4a: 4" of asphalt cap, 8" of stone, drainage net, synthetic liner, bentonite mat

Case 4a-1:   4" of asphalt cap, 8" of stone, drainage net

Case 5:   6" of topsoil, 12" of fill, synthetic liner, 12" of barrier soil, vegetated

Case 5a: 6" of topsoil, 12" of fill, drainage net, synthetic liner, 12" of barrier soil,
               vegetated

Case 6:   Existing conditions

The description of the procedure, as well as the summary of results, are outlined below. Printouts of HELP output files are attached.

1. OBJECTIVE

The objective of this analysis is to estimate the average annual infiltration for the capping systems considered for the South Landfill facility. The caps are as follows:

Case 1: 6" of topsoil

Case 2: 6" of topsoil
       12" of barrier soil

Case 2-1: 6" of topsoil
        12" of fill
        12" of barrier soil

Case 3: 6" topsoil
       bentonite mat

Case 3-1: 6" topsoil
        12" of fill
        bentonite mat

Case 3a: 6" topsoil
       drainage net
       bentonite mat

Case 3a-1: 6" topsoil
        12" of fill
        drainage net
        bentonite mat

Case 4: 4" asphalt
       8" stone
       synthetic liner
       bentonite mat

Case 4-1: 4" asphalt
        8" stone
        24" of waste

Case 4a: 4" asphalt
       8" stone
       drainage net
       synthetic liner
       bentonite mat

Case 4a-1: 4" asphalt
        8" stone
        drainage net
        24" of waste

Case 5: 6" of topsoil
       12" of fill
       synthetic liner
       12" of barrier soil

Case 5a: 6" of topsoil
       12" of fill
       drainage net
       synthetic liner
       12" of barrier soil

Case 6: Existing cover of 3' of silty/clayey soil

Note that the only difference between cases 3, 4, 5 and 3a, 4a, 5a is the presence of the drainage net. Cases 2-1, 3-1 and 3a-1 are introduced to investigate the effect of an additional 12" layer of fill on Cases 2, 3 and 3a. Cases 4-1 and 4a-1 differ from Cases 4 and 4a in that they lack the synthetic liner and the bentonite mat. The layer of waste in Cases 4-1 and 4a-1 is introduced because a lateral drainage layer, such as stone or drainage net, can not be the lower-most layer in HELP.

2. DESIGN DATA

Climatological data

Climatological data was selected from the HELP data base for the location of Wilmington, DE. The daily precipitation, temperature and solar radiation input was generated synthetically for the period of 100 years.

Evapotranspiration data

Evapotranspiration parameters pertaining to the climatological data are obtained from the HELP data base for the location of Wilmington, DE.

In typical topsoils vegetated with grass, the evapotranspiration zone depth in relatively moist climates, such as in Delaware, is likely to be approximately 21 inches. Value of 21 inches was used in this calculation. However, the thickness of the zone available for the root growth is less than that for all cases considered in this analysis, except for Cases 2-1 and 6. For the remaining cases either the entire thickness of the cap is less than 21 inches or the thickness available for root growth is limited by the presence of the bentonite mat or a synthetic liner. Therefore, the actual depths of the evapotranspiration zone are:

Case 1: $d = 6$ inches
Case 2: $d = 18$ inches
Case 2-1: $d = 21$ inches
Case 3: $d = 6$ inches
Case 3-1: $d = 18$ inches
Case 3a: $d = 6$ inches
Case 3a-1: $d = 18$ inches
Case 5: $d = 18$ inches
Case 5a: $d = 18$ inches
Case 6: $d = 21$ inches

Note that the details of the cap construction are not yet specified. If fill is placed to create a uniformly graded subgrade, the evapotranspiration zone may extend deeper into the fill. Also, depending on the nature of the waste, the root growth may occur within the waste itself. For this analysis, it was assumed that there is no grading fill, and that the roots will not grow into the waste.

The cap configuration in Cases 4, 4-1, 4a and 4a-1 is different from the remaining cases because the surface is covered with asphalt. This, for all practical purposes, eliminates the evapotranspiration. Therefore, only a nominal evapotranspiration zone was assumed ($d = 0.1$ inches).

The maximum leaf area index was selected to be 2.0, based on the typical value for the poor to fair stand of grass.

LAI = 2.0

For the asphalt cap, the maximum LAI is zero (no vegetation).

Runoff parameters

It was assumed that the typical slopes of the landfill surface will be 4 percent, and that surface water collection swales will be located every 200 feet. The surface type for the calculation of the CN curve number was based on a poor stand of grass.

S = 4 %
L = 200 feet
Poor grass

For the asphalt cap, the CN number was user-specified at the value of 95. This was assumed based on the TR55 guidance for asphalt parking lots.

Soil data

Soil and material types were selected from the HELP data base. Properties are listed in Table 4 of the HELP manual. Short descriptions are provided below:

Existing soil:	HELP soil type #12, silty clay
Topsoil:	HELP soil type #6, sandy loam
Fill:	HELP soil type #4, loamy sand
Barrier soil:	HELP soil type #16, barrier soil (clay), hydraulic conductivity = $1*10^{-7}$ cm/s
Stone:	HELP soil type #21, gravel
Bentonite mat:	HELP material type #17
Synthetic liner:	HELP material type #36, LDPE, 40 mil, good quality installation
Drainage net:	HELP material type #20

Asphalt was modeled by assuming that its properties are similar to those of a barrier soil layer (HELP soil #16). This is probably a good assumption regarding hydraulic conductivity (on the order of 10^{-7} cm/sec). Remaining soil properties, such as wilting point and field capacity, are probably not relevant to asphalt.

The waste was modeled as a clayey soil with the hydraulic conductivity of $1.7*10^{-5}$ cm/s (HELP soil #15).

3. RESULTS

Average annual infiltration values are presented below:

Case	Description	Average Annual Infiltration [in/yr]
Case 1:	6" of topsoil, vegetated	16 (9) – see note below
Case 2:	6" of topsoil, 12" of barrier soil, vegetated	0.002
Case 2-1:	6" of topsoil, 12" of fill, 12" of barrier soil, vegetated	1.0
Case 3:	6" of topsoil, bentonite mat, vegetated	0.3
Case 3-1:	6" of topsoil, 12" of fill, bentonite mat, vegetated	1.1
Case 3a:	6" of topsoil, drainage net, bentonite mat, vegetated	0.02
Case 3a-1:	6" of topsoil, 12" of fill, drainage net, bentonite mat, vegetated	0.02
Case 4:	4" of asphalt cap, 8" of stone, synthetic liner, bentonite mat	zero
Case 4-1:	4" of asphalt cap, 8" of stone, waste	0.1
Case 4a:	4" of asphalt cap, 8" of stone, drainage net, synthetic liner, bentonite mat	zero
Case 4a-1:	4" of asphalt cap, 8" of stone, drainage net, waste	0.1
Case 5:	6" of topsoil, 12" of fill, synthetic liner, 12" of barrier soil, vegetated	0.008
Case 5a:	6" of topsoil, 12" of fill, drainage net, synthetic liner, 12" of barrier soil, vegetated	0.00005
Case 6:	Existing conditions	6

Note: In cases 1 and 2, there is a possibility that the roots can extend below the cap into the waste. For case 2 the difference in the depth of the evapotranspiration zone would be insignificant (from 18 to 21 inches), and the resulting infiltration would be practically the same as reported above. However, the difference would be significant for case 1, where the depth would increase from 6 to 21 inches. Assuming that, the infiltration decreased from 16 to 9 inches.

4. SUMMARY

Results can be summarized as follows:

- Under existing conditions or a soil cap, the average infiltration would be on the order of 10 inches per year (Cases 1 and 6).
- For the low perm soil cap the infiltration should be negligible (Case 2, I = 0.002 in/yr obtained). However, the 6" topsoil would not create a sufficient barrier for frost penetration. The low permeability barrier soil would be likely to crack and/or heave, causing an increase in infiltration whose magnitude is impossible to predict. The frost damage can be controlled by an addition of a frost protection layer. However, the frost protection layer itself creates a reservoir by trapping water above the low permeability barrier and thus increasing the head acting on the barrier. As a result, the infiltration is on the order of 1 inch per year (Case 2-1). The same is true if bentonite mat is used instead of the low permeability barrier soil (Case 3 and 3-1). The addition of a lateral drainage layer above the low permeability barrier or bentonite mat would decrease the infiltration to a negligible level (Cases 3a and 3a-1, I = 0.02 in/yr).
- The asphalt cap with the liner and bentonite mat will practically eliminate all infiltration (Cases 4 and 4a, I = 0). If the liner and bentonite are not used and the cap is constructed directly above the waste, the infiltration would still be ⬤ very low (Cases 4-1 and 4a-1, I = 0.1 in/yr). In all cases, the presence of the drainage net has no effect on the performance of the asphalt cap. This is because the 8-inch stone layer has sufficient lateral flow capacity to convey the insignificant amount of water infiltrating through asphalt at negligible heads.
- The RCRA cap without the drainage net will allow only negligible infiltration (Case 5, I = 0.008 in/yr). The addition of a drainage net would practically eliminate all the infiltration (Case 5a, I = 0.00005 in/yr, essentially zero).

ROD REMEDY ESTIMATE

NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
ROD REMEDY

Description	Quantity	Unit	Unit Cost		Total Cost	
Site Preparation	16	Acre	$	12,300	$	196,800
Soil Stabilization						
Soil Cement Shallow Auger Mixing	500,000	CY	$	16.00	$	8,000,000
Cement Additive	500,000	CY	$	3.50	$	1,750,000
Subtotal					$	9,750,000
Soil Consolidation and Backfill	77,000	CY	$	19	$	1,463,000
Soil Cap	16	Acre	$	21,000	$	336,000
Riverbank Protection	2,000	CY	$	58.45	$	116,900
Direct Cost Subtotal					$	11,862,700
General Conditions	100%	Lump Sum		Nec.	$	760,000
Main Office Overhead	7.7	Percent	$	11,862,700	$	913,428
Profit	10	Percent	$	11,862,700	$	1,186,270
Engineering and Project Support	7	Percent	$	11,862,700	$	830,389
Monitoring and Maintenance	100%	Lump Sum		Nec.	$	25,000
Subtotal					$	15,577,787
Contingency	5	Percent	$	15,577,787	$	778,889
TOTAL					$	16,356,676

NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
ROD REMEDY

Assumptions:

Assume 500,000 cy of soil to be treated, quantity furnished by WCD on 2/14/00

Assume 4 - 8' dia. shallow soil mixing augers will be used concurrently

Cap Tie-ins to Old Airport Road => ref: URS PRW backup

Riverbank Protection => ref: URS PRW backup

Assume $25,000 per year per Brandt Butler telecon 4/20/00

Main Office Overhead @ 7.7% is from 2000 Means (Heavy Construction)

Engineering and Project Support: use 7% URS average for work of this nature

Profit is assumed to be 10%

A 5% contingency has been added at the discretion of the estimator

All manpower, equipment, unit costs, productivity, quantities, etc. have been discussed and verified with Geo-Con

ROD REMEDY

Current Prevailing Labor/Wage Rates – New Castle County, Delaware

	Hrly. Base Rate	PT & I	Loaded Hrly. Rate
Labor Forman	$25.68	35%	$34.67
Laborer	$24.58	35%	$33.18
Operating Engineer (crane)	$34.76	35%	$46.93
Operating Engineer (oiler)	$28.55	35%	$38.55
Operating Engineer	$34.76	35%	$46.93
Operating Engineer (medium)	$32.16	35%	$43.42
Truck Driver	$22.10	35%	$29.84

Equipment Rental Rates

	2000 Means	Monthly rate ÷ hr./mo.	= hrly. rate	+ hrly. op.cost	= hrly. rate
1½ cy Backhoe	016-408-0200	$7,500/mo. ÷ 176 hrs.	= $42.60	+ $26.60/hr.	= $69.20/hr.
1¾ cy Loader	016-408-4650	$3,650/mo. ÷ 176 hrs.	= $20.75	+ $12.50/hr.	= $33.25/hr.
50 HP Dozer	016-409-4200	$5,530/mo. ÷ 176 hrs.	= $31.75	+ $17.00/hr.	= $48.75/hr
Diesel Generator 30 KVA	016-420-2600	$1,100/mo. ÷ 176 hrs.	= $6.25	+ $6.86/hr.	= $13.11/hr.
Watson Auger w/DBL Kelly Model 2500C	Blue Book	$17,955/mo. ÷ 176 hrs.	= $102.01	+ $39.55/hr.	= $141.56/hr.
Link Belt Crawler Crane 136T Model LS278H	Blue Book	$19,145/mo. ÷ 176 hrs.	= $108.80	+ $51.85/hr.	= $160.65/hr.

ROD REMEDY (cont'd.)

Batch Plant Model

65-110 YPH	Blue Book	$5,190/mo.	÷ 176 hrs. =	$29.50	+	$8.25/hr.	= $37.75/hr.
Pumps	Geo-Con	$500/wk.	÷ 40 hrs./wk.				= $12.50/hr
Storage Silo	Geo-Con	$500/wk.	÷ 40 hrs./wk.				= $12.50/hr

Truck Rental Rates

	2000 Means	Monthly rate ÷	hr./mo. =	hrly. rate+		hrly. op.cost	= hrly. rate
Concrete Truck	016-406-3300	$9,225/mo.	÷ 176 hrs. =	$ 52.50	+	$32.50/hr.	= $85.00/hr.
Dump Truck	016-408-5250	$3,375/mo.	÷ 176 hrs. =	$19.20	+	$17.40/hr.	= $36.60/hr.
Water Truck	016-420-6900	$700/wk.	÷ 40 hrs. =	$17.50	+	$11.07/hr.	= $28.57/hr.

ROD REMEDY

Site Preparation

The South Landfill site is approximately 16 acres

16 acres x 43,560 sf/ac = 696,960 sf

The site contains a holding cell, constructed of earthen berms, and a cleared area with stone roads including a parking area. Assume 1/3 of the site is to have medium trees cut and chipped with stumps chipped and grubbed. Brush hog 1/3 of the site to remove brush and small trees.

Site grading includes the collapsing the earthen berms prior to soil stabilization and the installation of a soil cap.

2-dozers w/ operators, 1-loader w/operator, 2-trucks w/drivers, 1-labor foreman, 2-laborers

696,960 sf ÷ 20,000 sf/day = **35 Days**

Dozer	560 hrs. x $48.75/hr.	=		$27,300
Loader	280 hrs. x $33.25/hr.	=		$ 9,310
Truck	560 hrs. x $36.60/hr.	=		$20,496
Operator	840 hrs. x $46.93/hr.	=		$39,421
Truck Driver	560 hrs. x $28.84/hr.	=		$16,206
Labor Foreman	280 hrs. x $34.67/hr.	=		$ 9,708
Laborer	560 hrs. x $33.18/hr.	=		$18,581
		Subtotal		$141,022

ROD REMEDY (cont'd.)

Site Preparation

2000 Means

Chip Trees	021-104-0200	6 acres x $3,275/ac.	=	$19,650
Grub Stumps	021-104-0250	6 acres x $2,180/ac.	=	$13,080
Brush Hog	021-108-0600	6 acres x $3,094/ac.	=	$18,564
Erosion Control	022-704-1100	3,650 lf x $2.60/lf.	=	$4,380
		Subtotal		$55,674
		Subtotal, previous page		$141,022
		Total	$196,696 ÷ 16 ac. = ~	$12,293.50 per acre
		SAY		**$12,300 per acre**

SOIL CEMENT

Shallow Auger Mixing

The South Landfill site is ~16 acres, ref. Nancy Griskowitz e-mail dated 2/3/00

16 acres x 43,560 sf/ac = 696,960 sf

Area of caisson = 3.1417 x 4^2 x 80% (overlap) = 40 sf/hole

Assume 2 holes/hr, therefore, assume 18 holes/day considering lost time and startup

18 holes/day x 40 sf/hole = 720 sf/day (10 hour per day)

696,960 sf ÷ 720 sf/day = 968 days to drill and inject cement

Allow crane and drill rig with operator & oiler, hoe with operator, batch plant

2-pumps, 2-silos with/ operator, 1-labor foreman, & 3-laborers for 968 days at 10 hr. per day (laborers & operators @ 11 hrs./day)

Crane	9,680 hrs.	x	$160.65	=	$1,555,092
Drill Rig	9,680 hrs.	x	$141.56	=	$1,370,301
Operator	10,648 hrs.	x	$46.94	=	$499,817
Oiler	10,648 hrs.	x	$38.55	=	$410,480
Backhoe	9,680 hrs	x	$69.20	=	$669,856
Operator	10,648 hrs.	x	$46.93	=	$499,711
Batch Plant	9,680 hrs.	x	$37.75	=	$365,420
Silo	19,360 hrs.	x	$12.50	=	$242,000
				Subtotal	$5,612,677

SOIL CEMENT (cont'd.)

Pump	19,360 hrs. × $12.50	=	$242,000
Med. Operator	10,648 hrs. × $43.42	=	$462,336
Labor Foreman	10,648 hrs. × $34.67	=	$369,166
Labor	31,944 hrs. × $33.18	=	$1,059,902
	Subtotal		$2,133,404
	Subtotal, previous page		$5,612,677
	Total		$7,746,081 ÷ 500,000 cy = $15.49/cy
	SAY		**$16 per cy**

AR324582

CEMENT ADDITIVE

Use 3% cement by volume

500,000 cy x 3% = 15,000 cy

15,000 cy x 2,550 lbs/cy = 38,250,000 lbs ÷ 2,000 lbs./ton = 19,125 ton, SAY 19,200 ton

Telecon quote from St. Mary's Cement Co., Delaware Office on 2/11/00 => $85/ton delivered to Newport Site (2001 price)

19,200 ton x $85/ton = $1,632,000 ÷ 500,000 cy = $3.26/cy,

SAY $3.50 per cy

HYDRATED LIME ADDITIVE

Use 3% hydrated lime by volume

500,000 cy x 3% = 15,000 cy

15,000 cy x 810 lbs/cy = 12,150,000 lbs ÷ 2,000 lbs/ton = 6,075 ton,

SAY   6,100 ton

There is no material cost for the hydrated lime, only shipping costs

Assume 800 mile haul distance (round trip) from Montague, Michigan

2/17/00 quote from Serafini Trucking, Tonawanda, NY - $1.75 to $2.00 per mile to haul lime

Use $2.00 per mile for hauling

800 miles x $2.00/mile => $1,600 per truck per trip

$1,600 per truck per trip ÷ 28 cy per truck per trip = $57.14/cy, **SAY $57 per cy**

28 cy x 810 lbs/cy = 22,680 lbs ÷ 2,000 lbs./ton = 11.34 ton, SAY 12 ton

$1,600 per truck per trip ÷ 12 ton per truck per trip => $133/ton, **SAY $135 per ton**

ROD REMEDY

Soil Consolidation and Backfill – Between Old Airport Road & Rte. 141

Area 1: 950 lf x 90 lf   = 85,500 sf

Area 2: ½ x 950 lf x 110 lf   = 52,250 sf
                                137,750 sf

137,750 sf x 15 ft. = 2,066,250 cf ÷ 27 cf/cy = 76,528 cy

                            SAY 77,000 cy

Equipment Rental

2000 Means

Backhoe 2 ½ cy	016-408-0320	$18,300/Mo. ÷ 176 hrs. = $104.00 + $59.00	=	$163.40/hr.
Off-Highway 35 ton	016-408-5600	$11,700/Mo. ÷ 176 hrs. = $66.50 + $32.30	=	$98.80/hr.
Vibratory Roller	016-408-3320	$6,900/Mo. ÷ 176 hrs. = $39.20 + $26.70	=	$65.90/hr.

Backhoe will load 10 trucks per hr. or 200 cy/hr

Three trucks will each make 3 1/3 trip/hr.

Cross Road – Short Haul
48 day required to excavate and move waste

This material would require soil treatment on west side of road. Assume treatment at 50% cost as auger would be in place.
Cement would still be required

Therefore excavate $18.67/cy treatment credit (50% x $16 = $8 added/cy to excavate the eastside, $16.67 - $8.00 = $10.67)

Excavation add 77,000 cy x $10.67/cy = $821,590, **SAY $821,600 cost savings to stabilize soil in place**

ROD REMEDY (cont'd.)

Soil Consolidation and Backfill – Between Old Airport Road & Rte. 141

1-2 ½ cy backhoe. 1-operator, 3-off-road trucks w/ drivers, 1-labor foreman. 1-laborer; 48-days for excavation

2-laborers; 48-days for flagging @ road crossing

3-laborers; 6-days to erect, maintain, and remove traffic control

1-dozer w/ operator, 1-laborer; 48-days to grade soil

2-dozer w/ operators, 1-roller w/ operator, 1-laboror; 48-days to place borrow

1-dozer w/ operator, 1-roller w/ operator, 1-laboror; 3-days to grade and clean up

Unit Price Development

Construction sign	12 ea x 16 sf x $20.00/sf	=	$3,840
Common Fill	77,000 cy x 10% compaction x $11.25/cy	=	$952,875
Backhoe	384 hrs. x $163.40/hr.	=	$62,746
Off Road	1,152 hrs. x $98.80/hr.	=	$113,818
Operator	384 hrs. x $46.93/hr.	=	$18,021
Oiler Driver	1,152 hrs. x $38.55/hr.	=	$44,410
Labor Foreman	384 hrs. x $34.67/hr.	=	$13,313
Laborer	384 hrs. x $33.18/hr.	=	$12,741
Flag Laborer	768 hrs. x $33.18/hr.	=	$25,482
Laborer	144 hrs. x $33.18/hr.	=	$4,778
Dozer	384 hrs. x $48.75/hr.	=	$18,720
Operator	384 hrs. x $46.93/hr.	=	$18,021
		Subtotal	$1,288,765

AR324585

ROD REMEDY (cont'd.)

Soil Consolidation and Backfill – Between Old Airport Road & Rte. 141

Laborer	84 hrs.	x	$33.18/hr.	=	$12,741
Dozer	768 hrs.	x	$48.75/hr.	=	$37,440
Roller	384 hrs.	x	$65.90/hr.	=	$25,306
Operator	1,152 hrs.	x	$46.93/hr.	=	$54,063
Laborer	384 hrs.	x	$ 33.18/hr.	=	$12,741
Dozer	24 hrs.	x	$48.75/hr.	=	$1,170
Roller	24 hrs.	x	$65.90/hr.	=	$1,582
Operator	48 hrs.	x	$46.93/hr.	=	$2,253
Laborer	48 hrs.	x	$33.18/hr.	=	$1,593

Subtotal $148,889

Subtotal, previous page $1,288,765

Total $1,437,654 ÷ 77,000 cy = 18.67/cy

SAY **$19 per cy**

ROD REMEDY

Soil Cap

Soil cap consists of 6-inches of topsoil with seeding

16 acres x 43,560 sf/ac = 696,960 sf

696,960 sf x 6-inches = 348,480 cf ÷ 27 cf/cy = 12,907 cy

SAY   13,000 cy

Unit prices from Chautauqua County Landfill (project bid late 1999)

Place topsoil	13,000 cy x	$4.00/cy	=	$52,000
Topsoil Material	13,000 cy x	$18.00/cy	=	$234,000
Seeding	16 acre	x $2,500/ac	=	$40,000
			Total	$326,000 ÷ 16 ac. = $20,375 per acre
			SAY	**$21,000 per acre**

GENERAL CONDITIONS

Project Schedule

1)	Mobilization	15 days
2)	Clear and Grub	6 days
3)	Soil Cement (968 days ÷ 4 rigs)	242 days
4)	Site Grading	33 days
5)	Modified Cap	45 days
6)	Demobilization	10 days

339 days ÷ 5 days = 68 weeks

2000 Means

Office Trailer Means	015-904-0500	17 months x $315/mo.	=	$5,355
Telephone	010-034-0140	17 months x $235/mo.	=	$3,995
Light & Heat	010-034-0160	17 months x $88/mo.	=	$1,496
Office Supplies	010-034-0120	17 months x $85/mo.	=	$1,445
Office Equipment	010-034-010	17 months x $133/mo.	=	$2,261
Port-a-John	016-420-6450	17 months x 4 ea. x $165/mo.	=	$11,220
Superintendent	010-036-0260	68 weeks x $1,245/wk. x 135%	=	$114,291
Project Manager	010-036-0200	68 weeks x $1,320/wk. x 135%	=	$121,176
			Subtotal	$261,239

GENERAL CONDITIONS (cont'd.)

Master Mechanic-Crane Rate		$38.24 + 10% = $42.06 x 110% x 48 hrs. x 68 weeks	=	$151,012
Survey	013-306-120	20 days x $575/day x 135%	=	$15,525
Equipment Mobilization and Setup	Geo-Con	Lump Sum	=	$150,000
Small Tools	010-082-0100	$11,745,800 x 0.5%	=	$58,729
Equipment & Mobilization	Geo-Con	Lump Sum	=	$50,000
Handtools & Mat'l. Deliveries Assume 3/wk.	022-274-1150	78 ea. x $100/ea.	=	$7,800
Insurance	010-040-0450	$11,745,800 x 0.5%	=	$58,729
Construction Photos 10/mo.	013-803-0200	17 mo. x $190/mo.	=	$3,323
			Subtotal	$495,118
			Subtotal, previous page	$261,239
			Total	$756,357
			SAY	$760,000

URS Greiner Woodward Clyde

Page ___ of ___

Job _Dupont_   Project No. ___   Sheet _1_ of ___

Description _Alternate Exc East Side_   Computed by _RD_   Date _01/2/00_

Checked by _HEW_   Date _01/29/00_

Reference
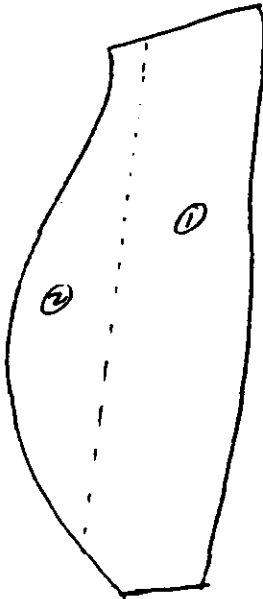
$$\text{Area} \quad 1 \quad 95 \times 90 = 85500 \checkmark$$
$$2 \quad \tfrac{1}{2} \times 95 \times 110 = 52250 \checkmark$$
$$137750 \checkmark$$

$$Vol \quad 137750 \times 15 = 2066250 \div 27 = 76500 \, cy$$

Equipment Rental

			oncost		
Backhoe 2½ cy means 016.408.0320   18300/mo ÷ 176 = 104$\frac{z}{00}$ + 59$\frac{oo}{}$ = 163$\frac{40}{}$

Off Highway 35 Ton   016.408.5600   11700/mo ÷ 176 = 66$\frac{50}{}$ + 32$\frac{z}{}$ = 98$\frac{80}{}$ ✓

Vib Roller sheepfoot   016.408.3320   6900/mo ÷ 176 = 39$\frac{00}{}$ ✓ + 26$\frac{00}{}$ = 65$\frac{00}{}$ ✓

HOE will Load 10 Trks / HR or 200 cy / HR

Three trucks will each make 3⅓ trip / HR
Cross Road - Short Haul
48 DAY Required to Exc & move

This matl would require soil treatment on West side
of Road. Assume Treatment at 50% cost as Auger
would be in place. Cement would still be Required
Treatment credit

Therefore   18$\frac{75}{}$ /cy − (50% off) = 11$\frac{45}{}$ added /cy To Exc East Side

Exc add   76500 cy × 11$\frac{45}{}$/cy = $875 925$$\frac{00}{}$ ✓

ROD REMEDY

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$326,000 ÷ 16 ac = $20.375 per acre

SAY $21,000 per acre

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Insurance	010-040-0450	$10,916,000 x 0.5%	=	$ 54,580
Construction Photos 10/mo.	013-803-0200	17 mo. x $190/mo.	=	$ 3,323

$747.969

SAY $750,000

TELEPHONE BID

URS
CONSULTANTS, INC.

Name and Address of Firm Submitting Bid:	Description of Project Being Bid On:
ST MARYS CEMENT CO DELAWARE OFFICE	DuPont

Vendor's Representative:	Vendor's Phone No.:
Chuck Green	1-800-365-0881

Terms:	Delivery Data:	FOB:
	Del in 2001	☐ Prepaid ☐ Collect
		Subject to Inspection

Quantity	Description	Unit Price	Total
125000	TON Portland Cement	85°°/ton	
	Note A Large Quantity As this over		'
	A 10 month Time Frame may		
	Require 2 Suppliers As 2 may		
	not have Total Amount of		
	Material Required		
	This is Anticipated cost for		
	Work in 2001		

Freight Costs	Sales/Use Tax	Total Cost for Labor	Total Cost for Material	Grand Total
$	$	$	$	$
Freight costs are sales tax exempt. - Always separate	☐ Tax Exempt	All Work and Material as per Plans and Specifications		☐ Yes ☐ No

Bid Inclusions:	Bid Exclusions

Date This Bid Phoned In:	Time This Bid Phoned In:	Signature of Representative Accepting This Bid:
02/11/00		
10:30	AM am pm	X

AR324594

URS Greiner

282 Delaware Avenue
Buffalo, New York 14202
(716) 856-5636

MEMO OF TELECON

JOB NO.: 0500035729.00 DATE: 01/21/00

JOB TITLE: DuPont FILE UNDER:

PERSON CALLING: Dick Davison PERSON CALLED: Mike Cavy

REPRESENTING: U.R.S REPRESENTING: Geo Con

TELEPHONE #: 1-412-856-7700

SUBJECT: Sol mixing At DuPont

SUMMARY OF CONVERSATION:

Soil mixing 100 to 150 Ton Crane mounted w/ 8' Ø Cassion Rig, Backhoe, Labor Foreman - 3 1/bk 2 mix Plants (500°/wk) 25KVA Generator - 2 Pumps (500°/wk) Silo & Storage Area

For production allow 2 cassions /hour use 80% off Volume to Allow for overlap $150,000° mobilization is required to move Equipment & Set up.

Cost should be 30° to 40°/cy or Less due to size of site 10 m Day Drill 17 to 18 holes /Day.

Cement should be 20% mix by Volume
Cost 80°/ton ÷ 2000° = .04/Pound

AR324595

CC:

ESD REMEDY ESTIMATE

NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
ESD REMEDY

Description	Quantity	Unit	Unit Cost	Total Cost
Site Preparation	16	Acre	$ 12,300	$ 196,800
Slurry Wall				
Bentonite	135	Ton	$ 135	$ 18,225
Common Fill	2,700	CY	$ 11.25	$ 30,375
Mixing & Placing Wall	21,800	SF	$ 4.60	$ 100,280
Subtotal				$ 148,880
	1	**SF**	**$ 6.83**	**$ 148,880**
Treatment with Sodium Sulfide	920,700	Lbs.	$ 0.40	$ 368,280
Crew	100	Days	$ 3,000	$ 300,000
Subtotal				$ 668,280
Treatment with Calcium Sulfate (gypsum)	34,000	Ton	$ 22	$ 748,000
Crew	462	Days	$ 3,000	$ 1,386,000
Subtotal				$ 2,134,000
Landfill Cap - bentonite mat, 12" cover soil, 6" topsoil	16	Acre	$ 77,255	$ 1,236,080
Riverbank Protection	2,000	CY	$ 58.45	$ 116,900
Road Crossings	2	Each	$ 1,000	$ 2,000
Cap Tie-ins to Old Airport Road	300	CY	$ 54.96	$ 16,488
Direct Cost Subtotal				$ 4,519,428
General Conditions	100%	Lump Sum	Nec.	$ 350,000
Main Office Overhead	7.7	Percent	$ 4,519,428	$ 347,996
Profit	10	Percent	$ 4,519,428	$ 451,943
Engineering and Project Support	7	Percent	$ 4,519,428	$ 316,360
Monitoring and Maintenance	100%	Lump Sum	Nec.	$ 25,000
Subtotal				$ 5,985,727
Contingency	5	Percent	$ 5,985,727	$ 299,286
TOTAL				**$ 6,285,013**

AR324597

NEWPORT SUPERFUND SITE
SOUTH LANDFILL REMEDY
ESD REMEDY

Assumptions:

Site Preparation Unit Cost: ref URS PRW Backup

Slurry Wall Unit Costs => ref. URS PRW Backup

Slurry Wall quantities from the URS PRW estimate

Calcium Sulfate (gypsum) quantity = Sodium Sulfate quantity; ref. attached WCD estimates

Gypsum quantity quantity => 67,500,000 lbs or 33,750 Ton, **SAY 34,000 Ton**

Gypsum cost => $0, ref. John Wilkens 12/1/99 e-mail & William Lacy Gray, Jr. Letter dated 2/11/00

Deliver gypsum => $22/Ton. ref. John Wilkens 12/1/99 e-mail & William Lacy Gray, Jr. Letter dated 2/11/00

Sodium Sulfide Costs/Crews from WCD estimates (see attached)

GCL & 18" soil cover cap => ref. URS PRW backup

Riverbank Protection => ref: URS PRW backup

Road Crossings => ref: URS PRW backup

Cap Tie-ins to Old Airport Road => ref: URS PRW backup

Assume $25,000 per year per Brandt Butler telecon 4/20/00

General Conditions Cost => ref. URS PRW backup

Main Office Overhead @ 7.7% is from 2000 Means (Heavy Construction)

Engineering and Project Support: use 7% URS average for work of this nature

Profit is assumed to be 10%

A 5% contingency has been added at the discretion of the estimator

To: John Wokasien/Buffalo@URSGreiner
cc: "Brandt Butler" <Brandt.Butler@USA.dupont.com>

Subject: SLF Cost Estimate Information

John,

The attached file contains two spreadsheets. The information on these sheets replaces the groundwater pumping and chemical treatment sections of the ESD estimate.

In addition, the Engineering and Project Support percentage of 10% that we include with our estimates includes but is not limited to treatability studies, pilot studies, implementation design, contract administration, health and safety compliance and field supervision.

(See attached file: Cost Estimates 1-27.xls)

Please let me know if you have any additional questions.

Thanks,
Nancy

- Cost Estimates 1-27.xls

COST ESTIMATE SUMMARY
NEWPORT SOUTH LANDFILL

Remediation Cost Estimate -- Low End
Site: Newport
Size: 15 Acres
Location: Newport, Delaware

Description	Quantity	Units	Unit Cost	Total Cost ($M)
Soil -- 15 Acre Site				
Treatment with Sodium Sulfate (Na$_2$SO$_4$)	67,500,000	lbs	$0.16	$10,800
Crew (231 days for 2 crews = 462 days)	462	days	$3,000	$1,386
SUBTOTAL				$12,186
Engineering and Project Support	10%			$1,219
TOTAL				$13,405

Notes:
1) Approximately 1.35 billion lbs of soil to be treated.
2) Soil: 100lb/ft^3
3) Treatment Ratio: 0.05 lb of Na$_2$SO$_4$ per lb of soil
4) Cost of Na$_2$SO$_4$: $0.16/lb

Sodium Sulfate

COST ESTIMATE SUMMARY
NEWPORT SOUTH LANDFILL

Remediation Cost Estimate -- Low End
Site: Newport
Size: 3.3 Acres
Location: Newport, Delaware

Description	Quantity	Units	Unit Cost	Total Cost ($M)
Soil -- 3.3 Acre Site				
Treatment with Sodium Sulfide (Na₂S)	920,700	lbs	$0.40	$368
Crew	100	days	$3,000	$300
SUBTOTAL				$668
Engineering and Project Support	10%			$67
TOTAL				**$735**

Notes:
1) Treatment area for zinc only is 3.3 acres.
2) Soil: 100lb/ft³
3) Treatment Ratio: 0.0031 lb of Na₂S per lb of soil
4) Cost of Na₂S: $0.40/lb

AR324601